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OXFORD FORAY.

May 18th to 22nd, 1928.

By E. M. Wakefield.

The 1928 Spring Foray was held at Oxford during the week-end May 18th to 22nd. Through the kindness of Professor Tansley, two rooms at the Botanic Gardens were placed at the disposal of members for meetings and for the examination of specimens.

On Friday evening, May 18th, about twenty members assembled at the School of Rural Economy, and were shown over the laboratories and the Imperial Forestry Institute by Dr Woodward and Mr W. R. Day respectively.

Collecting began on Saturday with a visit to Bagley Wood. The weather previously had been dry and cold, and throughout the Foray the larger fungi were very scarce. At Bagley, however, it was interesting to see various tree diseases, which were demonstrated by Mr Day. Among others were shown bad attacks of *Cronartium ribicola* on *Pinus Strobus*, *Meria Laricis*, *Rhabdocline Pseudotsugae* on Douglas Fir, and *Keithia thujina* on nursery stock of *Thuja*. These and other microfungi chiefly made up the list for this wood, only two Agarics and a few other Basidiomycetes being found.

After lunch the party proceeded by charabanc to Cothill and then to Tubney Arboretum, where, however, little of note was recorded.

In the evening Professor Dame Helen Gwynne-Vaughan delivered a lecture, attended by students of the University, on "Heterothallism."

Sunday afternoon was spent in Blenheim Park, but here conditions were very dry and little was found.

Wytham Woods, visited on Monday, proved better ground from a mycological point of view. Here the ground was more moist, and there was abundance of cut branches and logs, which provided various wood-loving species. Particularly striking was the great abundance of the "Jew's Ear," *Auricularia auricula-Judae*, on old branches and trunks of elder. Among the more interesting microfungi found were *Calonectria Plowrightiana* on dead branches of sycamore, and *Peroneutypa heteracantha* on elder and oak.

After tea, which was kindly provided by Colonel ffennell, the owner of the Wytham estate, members were taken to the Sugar Beet factory at Eynsham, and shown the various stages of the extraction of sugar from sugar beet.

In the evening, Mr Ramsbottom gave a talk on "The Problem of Species in Fungi."

At the conclusion of the Foray, very hearty votes of thanks were passed to Professor Tansley, Dr Woodward, and other members of the botanical staffs of the University, for their assistance in making arrangements for the meeting, and to the various landowners who had granted permission for their grounds to be worked.

Complete List of Species gathered during the Foray.

B. = Bagley Wood; *C.* = Cothill; *T.* = Tubney Arboretum; *P.* = Blenheim Park; *W.* = Wytham Woods.

HYMENOMYCETES.

Armillaria mellea (Vahl) Fr., *B.* (causing canker on *Thuja plicata*).
Tricholoma Georgii (Clus.) Fr., *B.*, gambosum Fr., *P.*
Panus torulosus (Pers.) Fr., *C.*
Entoloma sericeum (Bull.) Fr., *B.*
Tubaria furfuracea (Pers.) W. G. Sm., *C.*
Hypholoma fasciculare (Huds.) Fr., *B.*, *W.*
Psathyrella atomata Fr., *P.*
Coprinus plicatilis (Curt.) Fr., *P.*
Polyporus squamosus (Huds.) Fr., *P.*, *W.*, and *Botanic Garden*, betulinus (Bull.) Fr., *W.*, adustus (Willd.) Fr., *P.*
Fomes igniarius (Linn.) Fr., on *Willow, Oxford.*
Ganoderma applanatum (Pers.) Pat., *P.*
Polystictus versicolor (Linn.) Fr., *C.*, *P.*, *W.*
Trametes gibbosa (Pers.) Fr., *W.*
Daedalea quercina (Linn.) Fr., *C.*, *W.*
Merulius Corium (Pers.) Fr., *C.*, *W.*
Irpex obliquus (Schrad.) Fr., *B.*, *W.*
Stereum hirsutum (Willd.) Fr., *B.*, *P.*, *W.*, rugosum (Pers.) Fr., *T.*
Peniophora quercina (Pers.) Cooke, *W.*, cinerea (Fr.) Cooke, *W.*, caesia (Bres.) Bourd. and Galz., *W.*, hydnoides Cooke & Mass., *W.*
Corticium Sambuci (Pers.) Fr., *W.*
Auricularia auricula-Judae (Linn.) Schroet., *C.*, *W.*
Dacryomyces deliquescens (Bull.) Duby, *B.*, *W.*

GASTEROMYCETES.

Lycoperdon depressum Bon., *B.*

UREDINALES.

Uromyces Ficariae (Schum.) Lév., *B.*, *T.*, Scillarum (Grev.) Wint., *B.*, *P.*, Poae Rabenh., *C.*, *P.* (Aecidium).
Puccinia Violae (Schum.) DC., *C.* (Aecidium), Anemones Pers., *B.*, *T.*, pulverulenta Grev., *W.*, obtegens (Link) Tul., *W.*, Caricis (Schum.) Rebent., *C.* (Aecidium), holcina Erikss., *B.*, Phragmitis (Schum.) Koern., *C.*, expansa Link, *P.*, persistens Plowr., *Godstow* (Aecidium).
Phragmidium mucronatum (Pers.) Schlecht., *C.*, violaceum (Schultz) Wint., *B.*, *W.*, Rubi (Pers.) Wint., *W.*
Cronartium ribicola Dietr., *B.* (Aecidium on *Pinus Strobus*).
Melampsora Rostrupii Wagn. (Aecidium), *B.*, *W.*
Melampsorella Symphyti (DC.) Bubak, *C.*, *W.*

USTILAGINALES.

Ustilago Lychnidis-dioicae (DC.) Liro, on *Melandrium rubrum, C.*, *W.*
Urocystis Anemones (Pers.) Wint., *B.*

DISCOMYCETES.

Cheilymenia subhirsuta (Schum.) Boud., *W.*
Trichoscypha calycina (Schum.) Boud., *B.*, *C.*
Dasyscypha virginea (Batsch) Fuck., *B.*, *C.*, nivea (Hedw. fil.), *W.*

Lasiobolus equinus (Mull.) Karst., *B.*
Bulgaria inquinans (Pers.) Fr., *C.*
Helotium fructigenum (Bull.) Fuck., *P.*, *W.*
Micropodia pteridina (Karst.) Boud., *P.*
Mollisia cinerea (Batsch) Karst., *W.*
Keithia thujina Durand, *B.*
Rhabdocline Pseudotsugae Syd., *B.*
Rhytisma acerinum (Pers.) Fr., *W.*

PYRENOMYCETES.

Erysiphe graminis DC., *C.*
Nectria coccinea (Pers.) Fr., *P.*, episphaeria (Tode) Fr., *W.*
Calonectria Plowrightiana Sacc., on *Sycamore*, *W.*
Rosellinia aquila (Fr.) de Not., *W.*
Bertia moriformis (Tode) de Not., *W.*
Strickeria obducens (Fr.) Wint., on *Ash*, *W.*
Stigmatea Robertiani Fr., *C.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *W.*
Pleospora herbarum Rabenh., *W.*
Ophiobolus porphyrogonus (Tode) Sacc., *W.*
Diaporthe Arctii (Lasch) Nits., *W.*, leiphaemia (Fr.) Sacc., *W.*, Niesslii Sacc. on *Sycamore*, *W.*
Eutypa lata (Pers.) Tul., *W.*
Peroneutypa heteracantha Sacc., on *Elder* and *Oak*, *W.*
Cryptosphaeria eunomia (Fr.) Fuck., *W.*
Diatrypella quercina (Pers.) Nits., *W.*
Diatrype Stigma (Hoffm.) de Not., *W.*, bullata (Hoffm.) de Not., on *Willow*, *C.*, disciformis (Hoffm.) de Not., *P.*
Hypoxylon fuscum (Pers.) Fr., *W.*, coccineum (Bull.) Fr., *P.*
Daldinia concentrica (Bolt.) Ces. & de Not., *C.*, *W.*
Ustulina vulgaris Tul., *P.*
Xylaria Hypoxylon (Linn.) Grev., *C.*, *W.*, carpophila (Pers.) Fr., *P.*, *W.*
Endodothella Junci (Fr.) Theiss. & Syd., *B.*
Rhopographus filicinus (Fr.) Nits., *B.*, *C.*, *W.*

PHYCOMYCETES.

Cystopus candidus de Bary, *C.*
Peronospora Ficariae Tul., *B.*
Plasmopara pygmaea (Unger) Schroet., *B.*, nivea (Unger) Schroet., on *Sanicula*, *P.*

DEUTEROMYCETES.

Macrophoma Fraxini Delacr., *W.*
Actinonema Rosae (Lib.) Fr., *W.*
Septoria Rubi West., *B.*, *W.*, Scillae West., *W.*
Cytosporina ramealis (Desm. & Rob.) Petrak, var. macrospora Appel, *B.*
Libertella faginea Desm., *T.*
Ovularia obliqua (Cooke) Oud., *P.*, *W.*
Ramularia Anthrisci v. Hoehn., *W.*, Primulae Thuem., *T.*, *W.*
Botrytis cinerea Pers., *C.*, *P.*
Meria Laricis Vuillem., *B.*
Cladosporium herbarum (Pers.) Link, *B.*
Bispora monilioides Corda, *B.*

LICHENS OF THE OXFORD FORAY.

By R. Paulson.

Bagley Wood, Tubney Wood and Wytham Woods cover a considerable portion of the area surveyed during the Foray. The first two, situated a short distance south-west of the city, are approximately four miles apart, centre to centre. There is

little difference in their size, but Bagley lies about sixty feet the higher (370 feet O.D.).

Such a small difference in height cannot account for the more luxuriant growth of lichens in Bagley Wood, where the handsome greenish yellow *Parmelia caperata* clothes the lower part of some of the oaks with a thallus measuring up to 24 × 18 inches, while in the lower wood, where the soil was decidedly damp, it was frequently only 4 × 5 inches. Fruiting specimens are not uncommon on walls within three miles of the city and a few occur on fences and walls within the city boundary. The crumbling stone of ancient buildings is unfavourable for lichen growth, but washing often reveals saxicolous species on the flakes of stone which have fallen from the city walls. The following species occur within the precincts of the colleges: *Lecanora galactinia, Candelariella vitellina, Buellia myriocarpa, Placodium murorum, Acarospora* sp., *Lepraria* (*Coccynia*) sp., and *Cladonia* sp.

Mr H. H. Knight has kindly furnished me with a list of the species collected by Mr D. A. Jones and himself on the visit to Wytham Woods. This includes the rather rare *Candelariella medians* and *Staurothele hymenogonia*. A large number of these species are calcareous.

The letters placed after the names of species indicate the localities in which the lichens were collected, viz.:

B. = Bagley Wood; *T.* = Tubney Wood; *H.* = High Lodge Wood; *W.* = Wytham Woods; *O.* = Oxford.

Chaenotheca melanophaea Zwackh., *T.*, *W.*
Calicium hyperellum Ach., *B.*, *H.*, *T.*, *W.*
Stenocybe septata Rehm, on *Holly*, *W.*
Cyphelium inquinans Trev., *B.*, *T.*
Placynthium nigrum S. F. Gray, *W.*
Peltigera canina Willd., *T.*
Candelaria concolor Wain, *T.*
Parmelia physodes Ach., common, perlata Ach., *T.*, caperata Ach., *B.*, *T.*, *H.*, *W.*, scortea Ach., *T.*, saxatilis Ach., *H.*, sulcata Tayl., *B.*, dubia Tayl., *T.*, revoluta Floerke, *W.*, fuliginosa Nyl. var. laetevirens Nyl., *B.*, *T.*
Evernia prunastri Ach., *B.*, *T.*, *H.*
Ramalina fastigiata Ach., *T.*, *H.*
Usnea florida Web., *B.* (very scarce), *H.*, var. hirta Ach., *B.* (very scarce), *H.*
Xanthoria parietina Th. Fr., *T.*, *O.*
Placodium callopismum Mér., *O.*, murorum DC., *T.* (wall), *O.*, pyraceum Anzi., *W.*, rupestre Branth & Rostr., *W.*
Candelariella medians A. L. Sm. (on wall in Wytham village), vitellina A. L. Sm., *T.* (wall), *O.*
Physcia pulverulenta Nyl., *T.*, *H.*, *O.*, hispida Tuckerm., *T.*, caesia Nyl., *T.* (wall), orbicularis Dalla Torre & Sarnth., *B.*, *T.*, var. virella Dalla Torre & Sarnth.
Rinodina sophodes Th. Fr., *H.*
Lecanora muralis Schaer., *T.* (wall), subfusca Ach., *B.*, *T.*, campestris B. de Lesd., *T.* (wall), atra Ach., *T.*, galactina Ach., *O.*, varia Ach., *B.*, *H.*, *T.*, *W.*, calcarea Sommerf., *T.*, *O.*, var. contorta Hepp., *W.*, var. Hoffmanni Sommerf., *T.* (wall), gibbosa Nyl., *T.* (wall).
Acarospora percaenoides ? Jatta (no mature apothecia, hence the identification presents difficulties), *O.*

Pertusaria faginea Leight., *B.*, *H.*, *T.*, pertusa Dal. Tor. & Sarnth., *T.*, wulfenii DC., *T.*
Diploschistes scruposus Norm., *O.* (on a fence).
Crocynia fragilis B. de Lesd., *O.* (on decaying moss of walls, hyphae with red corpuscles).
Cladonia sylvatica Hoffm., *T.*, pyxidata Hoffm. (frequent), fimbriata Hoffm., *B.*, furcata Schrad. (not common), parasitica Hoffm., *W.* (uncommon), macilenta Hoffm., *B.*, *T.*, *H.*
Gyalecta exanthematica Fr., *W.*
Lecidea quernea Ach., *H.*, coarctata Nyl., *T.* (wall), contigua Fr., *T.* (on loose stone), fuscorubens Nyl., *W.*
Biatorella pruinosa Mudd, *W.*
Biatorina Griffithii Massal., *W.*
Bilimbia sabuletorum Br. & Rostr., *W.*
Bacidea muscorum Mudd, *W.*
Buellia canescens de Not., *B.*, *T.*, *O.*, myriocarpa Mudd, *O.*
Opegrapha herpetica Ach., *H.*, atra Pers., *W.*, vulgata Ach., *W.*
Graphis elegans Ach., *H.*
Verrucaria viridula Ach., *T.* (loose stones), nigrescens Pers., *T.* (loose stone), muralis Ach., *W.*, *O.*
Staurothele hymenogonia Th. Fr., *W.*
Acrocordia gemmata Koerb., *W.*
Porina carpinea A. Zahlbr., *W.*

LITTLEHAMPTON FORAY

October 1st to 6th, 1928.

By E. M. Wakefield.

The thirty-second Autumn Fungus Foray and Annual General Meeting took place with headquarters at Littlehampton, Sussex, during the week October 1st to 6th, 1928, when between thirty and forty members and friends attended. By arrangement with Mr T. J. Briant, Chairman of the Littlehampton Nature and Archaeology Circle, and the manager of the Beach Hotel, the room used by the local Society at the Bungalow Café was secured for the week, for the exhibition of specimens and for evening meetings.

The Annual General Meeting was held on Monday evening, October 1st, when President and Officers for 1929 were elected as follows: President, Miss E. M. Wakefield; second Vice-President, Professor M. C. Potter; elected members of Council, Dr B. Barnes and Mr W. D. Buckley. The other officers were re-elected. An invitation from Professor Darbishire to hold the Autumn Foray in 1929 at Bristol was accepted, and it was agreed that the general programme for 1929 should be similar to that which has been carried out in recent years.

The glorious summer of this year in the south was not favourable to the growth of fungi, and although care had been taken

in planning excursions to select localities that might be reasonably damp, the larger fungi were less in evidence than in any Autumn Foray in recent years. At the same time, although individuals were few in number, a surprisingly large number of species occurred, some of considerable interest. For instance, during the first day's hunting in Rewell Wood, to the west of Arundel, one of the first forms encountered was *Boletus aurantiporus* Howse, a brilliantly coloured species that could not be overlooked, and is seldom recorded. In the same woods were found *Clitocybe decastes*, *Polyporus varius*, *P. picipes* and *P. nummularius*, *Amanita echinocephala*; and among microfungi, *Protomyces inundatus* Dang. on *Apium nodiflorum*.

The second day (Wednesday) was spent in the woodland and pasture country at Michel Grove. Here numerous standing dead trees and fallen logs provided especially timber-rotting fungi. Amongst a mass of *Pleurotus sapidus* at the foot of a dead elm was found a fine specimen of *Volvaria bombycina*. Among resupinate Basidiomycetes found on rotting branches were *Caldesiella italica*, *Poria viridans* and *Corticium lactescens*, etc. Other interesting species noticed were *Cortinarius triumphans* and *Clitocybe conglobata*. The party had been invited to tea by Miss F. Collins at the School of Nature Study and Gardening at Clapham. Here a stroll round the gardens added some parasitic fungi to the list, including *Heterosporium gracile*, which was abundant on leaves of various Irises.

On Thursday it had been arranged to work Eartham Wood and North Wood, both of which lie rather high. Owing to the dry conditions prevailing, a slight change in the programme was made, and the time before lunch was spent in a damp hollow of Rewell Forest, lying beside the Chichester Road, to the south of Rewell Wood. This ground proved excellent for Agarics, and made up the list with many of the usual species. Particularly good finds were *Lentinus fimbriatus* and *Cortinarius Queletii*. After lunch a move was made to Eartham, but the woods there proved very dry, and little was added to the lists in the way of fleshy fungi. Mr E. W. Mason subsequently reported, however, that this locality was richer in Pyrenomycetes than any of the others visited.

Arundel Park was the venue for Friday, but here again conditions were very dry. On this day was found the only Clavaria seen during the week, a rather poor specimen of *C. pistillaris*. At the end of the day the party were entertained to tea in Arundel by Mr Robinson, President of the Littlehampton Nature and Archaeology Circle.

During the week the following papers were read at evening meetings:

Tuesday. Presidential Address by Professor Dame Helen Gwynne-Vaughan: "Problems of Development in the Fungi."

Wednesday. Dr Alex. Smith and Mr W. C. Moore: "New and Interesting Plant Diseases."

Thursday. Col. C. Th. Green: Popular lecture on "Fungi and their Haunts."

Friday. At 5.30 Mr Ramsbottom lectured to the local Society on "Fairy Rings," and later in the evening Mr Carleton Rea commented on the finds of the week.

Mr Carleton Rea exhibited at the meeting numerous specimens of *Puccinia Gentianae* (Strauss) Mart. which he had recently found growing in great profusion on the leaves and stems of *Gentiana amarella* on Bredon Hill, Worcestershire. This species has been recorded previously on *Gentiana acaulis* and *G. verna*.

At the close of the meeting, very hearty votes of thanks were passed to the various landowners, and especially to those members of the Littlehampton Nature and Archaeology Circle who had assisted in the arrangements for the Foray.

For help in compiling the subjoined list of species the Secretary is especially indebted to Mr C. Rea, Mr Ramsbottom, Mr Pearson and Mr E. W. Mason (Pyrenomycetes).

Complete List of Species gathered during the Foray.

R. = Rewell Wood; *Rf.* = Small low-lying wood at south edge of Rewell Forest. *M.* = Michel Grove; *E.* = Eartham Wood and North Wood; *A.* = Arundel Park.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr., *R.*, mappa (Batsch) Fr., *M.*, *Rf.*, muscaria (Linn.) Fr., *M.*, *Rf.*, and var. aureola (Kalchbr.) Quél., *M.*, echinocephala Vitt., *R.*

Lepiota cristata (A. & S.) Fr., *Rf.*

Armillaria mellea (Vahl) Fr., *R.*, *M.*, *Rf.*, *E.*, *A.*, mucida (Schrad.) Fr., *R.*, *M.*, *E.*

Tricholoma rutilans (Schaeff.) Fr., *Rf.*, *E.*, *A.*, terreum (Schaeff.) Fr., *R.*, argyraceum (Bull.) Fr., *Rf.*, cinerascens (Bull. non Fr.) Quél., *A.*

Russula chloroides (Krombh.) Bres., *Rf.*, nigricans (Bull.) Fr., *R.*, *Rf.*, *A.*, adusta (Pers.) Fr., *Rf.*, lepida Fr., *Rf.*, cyanoxantha (Schaeff.) Fr., *R.*, foetens (Pers.) Fr., *R.*, ochroleuca (Pers.) Fr., *Rf.*, fellea Fr., *Rf.*, rosacea (Pers.) Fr., *R.*, fragilis (Pers.) Fr., *Rf.*, emetica (Schaeff.) Fr., *R.*, xerampelina (Schaeff.) Fr., *Rf.*

Mycena pura (Pers.) Fr., *R.*, Adonis (Bull.) Fr., *R.*, flavo-alba Fr., *Rf.*, *A.*, galericulata (Scop.) Fr., *R.*, *Rf.*, polygramma (Bull.) Fr., *R.*, *Rf.*, *E.*, *A.*, inclinata Fr., *Rf.*, *A.*, filopes (Bull.) Fr., *Rf.*, amicta Fr., *A.*, Iris Berk., *R.*, acicula (Pers.) Fr., *M.*, sanguinolenta (A. & S.) Fr., *R.*, galopus (Pers.) Fr., *R.*, setosa (Sow.) Fr., *A.*, capillaris (Schum.) Fr., *A.*

Collybia radicata (Relh.) Berk., *R.*, *M.*, *E.*, fusipes (Bull.) Berk., *R.*, *Rf.*, maculata (A. & S.) Fr., *Rf.*, velutipes (Curt.) Fr., *M.*, cirrhata (Schum.) Fr., *Rf.*, rancida Fr., *R.*

Marasmius peronatus (Bolt.) Fr., *R.*, esculentus (Wulf.) Karst., *Rf.*, conigenus Pers.) Karst., *Rf.*, erythropus (Pers.) Fr., *M.*, hariolorum (DC.) Quél., *R.*, dryophilus (Bull.) Karst., *M.*, *Rf.*, ramealis (Bull.) Fr., *R.*

Androsaceus androsaceus (Linn.) Pat., *R.*
Lactarius torminosus (Schaeff.) Fr., *Rf.*, turpis (Weinm.) Fr., *Rf.*, pubescens Fr., *E.*, blennius Fr., *R.*, pyrogalus (Bull.) Fr., *Rf.*, vellereus Fr., *R.*, *Rf.*, rufus (Scop.) Fr., *E.*, glyciosmus Fr., *Rf.*, subdulcis (Pers.) Fr., *R.*
Hygrophorus eburneus (Bull.) Fr., *R.*
Clitocybe aurantiaca (Wulf.) Studer, *Rf.*, decastes Fr., *R.*, cartilaginea (Bull. non Fr.) Bres., *E.*, conglobata (Vitt.) Bres., *M.*, *A.*, infundibuliformis (Schaeff.) Fr., *M.*
Laccaria laccata (Scop.) B. & Br., *R.*, *Rf.*
Omphalia gibba Pat., *A.*
Pleurotus sapidus Schulz., *M.*, mastrucatus Fr., *R.*, septicus Fr., *A.*
Lentinus cochleatus (Pers.) Fr., *R.*, fimbriatus Curr., *Rf.*
Panus stipticus (Bull.) Fr., *R.*
Volvaria bombycina (Schaeff.) Fr., *M.*
Pluteus cervinus (Schaeff.) Fr., *R.*, *A.*, salicinus (Pers.) Fr., *R.*, and var. floccosus Karst., *M.*, nanus (Pers.) Fr., var. lutescens Fr., *A.*
Nolanea pascua (Pers.) Fr., *R.*
Clitopilus prunulus (Scop.) Fr., *Rf.*
Paxillus involutus (Batsch) Fr., *R.*, *M.*, *Rf.*, atrotomentosus (Batsch) Fr., *R.*, *A.*
Pholiota radicosa (Bull.) Fr., *R.*, *E.*, squarrosa (Müll.) Fr., *A.*, spectabilis Fr., *R.*, *A.*, adiposa Fr., *R.*, *M.*, *A.*, mutabilis (Schaeff.) Fr., *M.*
Bolbitius titubans (Bull.) Fr., *A.*
Inocybe pyriodora (Pers.) Fr., *R.*, geophylla (Sow.) Fr., *R.*, *Rf.*, and var. lilacina Fr., *R.*
Hebeloma fastibile Fr., *Rf.*, testaceum (Batsch) Fr., *R.*, crustuliniforme (Bull.) Fr., *E.*
Galera ovalis Fr., *A.*, hypnorum (Schrank) Fr., *R.*
Tubaria furfuracea (Pers.) W. G. Sm., *R.*
Flammula ochrochlora Fr., *R.*
Cortinarius (Phlegmacium) triumphans Fr., *M.*, purpurascens Fr., *M.*
(Myxacium) elatior Fr., *A.*
(Dermocybe) lepidopus Cooke, *Rf.*, Queletii Bat., *Rf.*
(Telamonia) torvus Fr., *Rf.*, brunneus (Pers.) Fr., *Rf.*
Crepidotus mollis (Schaeff.) Fr., *R.*, calolepis Fr., *R.*
Stropharia aeruginosa (Curt.) Fr., *R.*, *Rf.*, inuncta Fr., *A.*, squamosa (Pers.) Fr., *R.*
Gomphidius viscidus (Linn.) Fr., *E.*
Hypholoma sublateritium (Schaeff.) Fr., *Rf.*, fasciculare (Huds.) Fr., *R.*, *Rf.*, *E.*, *A.*, pyrotrichum (Holmsk.) Fr., *R.*, velutinum (Pers.) Fr., *R.*, pilulaeforme (Bull.) Fr., *R.*, hydrophilum (Bull.) Fr., *R.*, *E.*, *A.*
Psathyrella gracilis Fr., *R.*, *A.*, prona Fr., *R.*, atomata Fr., *R.*, *Rf.*, disseminata (Pers.) Fr., *M.*
Psathyra conopilea Fr., *A.*
Panaeolus campanulatus (Linn.) Fr., *R.*
Psilocybe uda (Pers.) Fr., *Rf.*, semilanceata Fr., *M.*, *Rf.*
Coprinus comatus (Fl. Dan.) Fr., *R.*, *Rf.*, *E.*, atramentarius (Bull.) Fr., *E.*, micaceus (Bull.) Fr., *R.*, *A.*, lagopus Fr., *R.*, *E.*, domesticus (Pers.) Fr., *M.*, plicatilis (Curt.) Fr., *M.*, *Rf.*
Boletus viscidus (Linn.) Fr., *R.*, *A.*, granulatus (Linn.) Fr., *E.*, aurantiporus Howse, *R.*, chrysenteron (Bull.) Fr., *R.*, subtomentosus (Linn.) Fr., *R.*, *M.*, satanas Lenz, *A.*, erythropus (Pers.) Quél., *M.*, duriusculus Schulz., *R.*, scaber (Bull.) Fr., *Rf.*
Polyporus nummularius (Bull.) Quél., *R.*, M., picipes Fr., *R.*, varius Fr., *R.*, squamosus (Huds.) Fr., *A.*, on *Maple*, giganteus (Pers.) Fr., *R.*, *M.*, *E.*, betulinus (Bull.) Fr., *R.*, dryadeus (Pers.) Fr., *R.*, hispidus (Bull.) Fr., *R.*, *M.*, cuticularis (Bull.) Fr., *A.*, adustus (Willd.) Fr., *R.*, *M.*, caesius (Schrad.) Fr., *R.*, *M.*, stipticus (Pers.) Fr., *R.*
Fomes Ribis (Schum.) Fr., *R.*, ferruginosus (Schrad.) Mass., *R.*, *M.*, *A.*, ulmarius (Sow.) Fr., *M.*, fraxineus (Bull.) Fr., *A.*, annosus Fr., *R.*
Ganoderma applanatum (Pers.) Pat., *R.*, *M.*, *A.*
Polystictus versicolor (Linn.) Fr., *R.*, *M.*

Poria obducens (Pers.) Fr., *R.*, viridans Berk., *M.*, purpurea Fr., *R.*
Irpex obliquus (Schrad.) Fr., *R.*, *E.*, *A.*
Lenzites betulina (Linn.) Fr., *Rf.*
Trametes gibbosa (Pers.) Fr., *R.*, *M.*, rubescens (A. & S.) Fr., *A.*
Daedalea biennis (Bull.) Quél., *Rf.*, *A.*, quercina (Linn.) Fr., *R.*, *Rf.*
Merulius tremellosus (Schrad.) Fr., *R.*, *M.*, Corium (Pers.) Fr., *M.*, lacrymans (Wulf.) Fr., *A.*
Phlebia merismoides Fr., *R.*, *M.*, *A.*
Coniophora puteana (Schum.) Karst., *A.*, arida Fr., *R.*, *A.*
Fistulina hepatica (Huds.) Fr., *R.*
Hydnum repandum (Linn.) Fr., *R.*, Erinaceus (Bull.) Fr., *R.*
Acia uda (Fr.) Bourd. & Galz., *R.*, *M.*, *A.*, fusco-atra (Fr.) Pat., *Rf.*
Grandinia granulosa (Pers.) Fr., *M.*
Odontia fimbriata (Pers.) Fr., *R.*, bicolor (A. & S.) Bres., *R.*, farinacea (Pers.) Quél., *R.*, *M.*, *A.*
Caldesiella italica Sacc., *M.*
Hypochnus ferrugineus (Pers.) Fr., *R.*, umbrinus (Fr.) Quél., *R.*, fuscus (Pers.) Fr., *R.*, echinosporus (Ell.) Burt, *R.*
Thelephora anthocephala (Bull.) Fr., *R.*
Hypochnella violacea (Awd) Schroet., *R.*
Stereum rugosum (Pers.) Fr., *A.*, sanguinolentum (A. & S.) Fr., *R.*, hirsutum (Willd.) Fr., *R.*, purpureum (Pers.) Fr., *R.*
Corticium Sambuci (Pers.) Fr., *M.*, *A.*, botryosum Bres., *R.*, comedens (Nees) Fr., *A.*, porosum B. & C., *R.*, *E.*, praetermissum (Karst.) Bres., *R.*, lactescens Berk., *M.*, roseo-cremeum Bres., *R.*
Peniophora candida (Pers.) Lyman (= P. Aegerita v. H.), *R.*, *E.*, subalutacea (Karst.) v. Hoehn. & Litsch., *R.*, *M.*, pallidula Bres., *R.*, sphaerospora v. Hoehn. & Litsch., *M.*, byssoidea (Pers.) v. Hoehn. & Litsch., *R.*, longispora (Pat.) v. Hoehn. & Litsch., *R.*, *A.*, cremea Bres., *A.*, velutina (DC.) Cooke, *R.*, *M.*, *E.*, setigera (Fr.) Bres., *R.*, *M.*, *A.*, Molleriana (Bres.) Sacc., *R.*, hydnoides C. & M., *R.*, *E.*, incarnata (Pers.) Cooke, *A.*, cinerea (Fr.) Cooke, *M.*, *E.*, *A.*, laevigata (Fr.) Mass., *R.*, quercina (Pers.) Cooke, *R.*
Solenia poriaeformis (DC.) Fr., *M.*
Clavaria pistillaris (Linn.) Fr., *A.*
Pistillaria quisquiliaris Fr., *M.*, puberula Berk., *Rf.*
Auricularia mesenterica (Dicks.) Fr., *R.*, *M.*, *A.*, auricula-Judae (Linn.) Schroet., *M.* (on *Holly*), *A.*
Tremella mesenterica (Retz.) Fr., *E.*
Exidia Thuretiana (Lév.) Fr., *R.*
Sebacina incrustans (Pers.) Tul., *R.*, subhyalina Pears., *R.*
Eichleriella spinulosa (B. & C.) Burt, *M.*
Dacryomyces deliquescens (Bull.) Duby, *M.*
Calocera cornea (Batsch) Fr., *M.*, stricta Fr., *M.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *M.*
Lycoperdon caelatum (Bull.) Fr., *A.*, perlatum Pers., *E.*, pyriforme (Schaeff.) Pers., *R.*, *E.*
Geaster fimbriatus Fr., *R.*
Cyathus striatus (Huds.) Pers., *R.*
Scleroderma verrucosum (Vaill.) Pers., *R.*

UREDINALES.

Puccinia Violae (Schum.) DC., *R.*, *M.*, *A.*, Lychnidearum Link, *M.*, Circaeae Pers., *R.*, Saniculae Grev., *R.*, *M.*, Celakovskiana Bub., *M.*, Valantiae Pers., *R.*, Cirsii Lasch, *M.*, Primulae (DC.) Duby, *M.*, Glechomatis DC., *R.*, Menthae Pers., *R.*, *Rf.*, obscura Schroet., *R.*, Caricis (Schum.) Rebent., *A.*, graminis Pers., *R.*, holcina Erikss., *R.*, *A.*, Phragmitis (Schum.) Koern., *A.*
Triphragmium Ulmariae (Schum.) Link, *A.*

Phragmidium Potentillae (Pers.) Wint., *M.*, Sanguisorbae (DC.) Schroet., *M.*, mucronatum (Pers.) Schlecht., *R.*, Rubi (Pers.) Wint., *R.*, violaceum (Schultz) Wint., *R.*, *M.*
Kuehneola albida Magn., *R.*, *Rf.*
Coleosporium Campanulae (Pers.) Lév., *M.*, Senecionis (Pers.) Fr., *R.*, Sonchi-arvensis (Pers.) Lév., *R.*, Tussilaginis (Pers.) Kleb., *R.*
Pucciniastrum Circaeae (Schum.) Schroet., *R.*, *Rf.*, Epilobii (Pers.) Otth, *R.*, *E.*
Melampsora Hypericorum (DC.) Schroet., *R.*
Melampsoridium betulinum (Pers.) Kleb., *Rf.*

PYRENOMYCETES.

Sphaerotheca pannosa (Wallr.) Lév., *R.*, *M.*, Humuli (DC.) Burr., *M.*, *R.*
Podosphaera Oxyacanthae (DC.) de Bary, *M.*
Erysiphe cichoriacearum DC., *R.*, *M.*, Polygoni DC., *R.*, tortilis (Wallr.) Fr., *M.*
Microsphaera Alni DC., *R.*
Uncinula Aceris (DC.) Sacc., *R.*, *M.*
Phyllactinea corylea (Pers.) Karst., *R.*, *Rf.*, *E.*
Nectria cinnabarina (Tode) Fr., *R.*, *M.*, *A.*, coccinea (Pers.) Fr., *M.*, *E.*, sinopica Fr., *M.*
Hypomyces rosellus (A. & S.) Tul., *M.*
Hypocrea gelatinosa (Tode) Fr., *A.*
Epichloe typhina (Pers.) Tul., *A.*
Leptosphaeria ovina (Pers.) Fuck., *R.*
Rosellinia aquila (Fr.) de Not., *A.*
Bertia moriformis (Tode) de Not., *E.*
Melanomma pulvis-pyrius (Pers.) Fuck., *E.*, *R.*, *Rf.*
Mycosphaerella maculaeformis (Pers.) Schroet., *R.*, *Rf.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *M.*, *A.*, Rusci (Wallr.) Sacc., *R.*
Ophiobolus porphyrogonus (Tode) Sacc., *Rf.*
Diaporthe pulla Nits., on *Ivy*, *M.*, Eres Nits., on *Elm*, *M.*, leiphaemia (Fr.) Sacc., on *Oak*, *Rf.*, taleola (Fr.) Sacc., on *Oak*, *Rf.*, castanea (Tul.) Sacc., on *Sweet Chestnut*, *Rf.*
Eutypa spinosa (Pers.) Tul., on *Beech*, *M.*, Acharii Tul., on *Sycamore*, *R.*, flavovirens Tul., on *Hazel* and *Beech*, *R.*, *M.*, lata (Pers.) Tul., *A.*
Peroneutypa heteracantha Sacc., on *Beech*, *R.*, on *Elm*, *M.*
Eutypella stellulata (Fr.) Sacc., on *Elm*, *M.*
Anthostoma turgidum (Pers.) Nits., on *Beech*, *M.*
Cryptosporella compta (Tul.) Sacc., on *Beech*, *Rf.*
Melanconis stilbostoma (Fr.) Tul. (conidial), on *Birch*, *Rf.*
Sillia ferruginea (Pers.) Karst., on *Hazel*, *E.*
Quaternaria quaternata (Pers.) Schroet., on *Beech*, *M.*, *E.*, dissepta (Fr.) Tul., on *Elm*, *M.*
Diatrypella quercina (Pers.) Nits., on *Oak*, *Rf.*, verrucaeformis (Ehrh.) Nits., on *Beech*, *R.*, *M.*, *E.*
Diatrype Stigma (Hoffm.) de Not., on *Beech* and *Hazel*, *R.*, *E.*, disciformis (Hoffm.) Fr., on *Beech*, *R.*, *M.*, *E.*, on *Willow*, *Rf.*
Hypoxylon semi-immersum Nits., on *Oak*, *R.*, and *rotten wood*, *E.*, multiforme Fr., on *Birch*, *R.*, rubiginosum (Pers.) Fr., *R.*, *E.*, purpureum Nits., on *Ash*, *R.*, *M.*, *E.*, fuscum (Pers.) Fr., on *Hazel*, *R.*, *M.*, *E.*, coccineum Bull., on *Beech*, *Sweet Chestnut* and *Birch*, *R.*, *M.*, *E.*
Ustulina vulgaris Tul., on *Beech* and *Horse Chestnut*, *R.*, *M.*, *A.*
Xylaria Hypoxylon (Linn.) Grev., *R.*, *M.*, *E.*, carpophila (Pers.) Fr., *R.*, *M.*, *A.*, polymorpha (Pers.) Grev., *R.*, *A.*
Daldinia concentrica (Bolt.) Ces. & de Not., *R.*, *M.*, *A.*
Phyllachora graminis (Pers.) Fuck., *M.*
Dothidella Ulmi (Duv.) Wint., *R.*, *M.*
Rhopographus filicinus (Fr.) Nits., *R.*, *M.*, *Rf.*

HYSTERIALES.

Dichaena faginea Fr., *R.*, *M.*

DISCOMYCETES.

Helvella crispa (Scop.) Fr., *R.*
Lachnea hemispherica (Wigg.) Gill., *E.*
Coprobia granulata (Bull.) Boud., *M.*
Calycella citrina (Hedw.) Quél., *R.*, *M.*
Bulgaria inquinans (Pers.) Fr., *R.*, *M.*
Orbilia xanthostigma Fr., *R.*, *M.*, *A.*
Phialea echinophila (Bull.) Quél., *Rf.*
Chlorosplenium aeruginosum (Oeder) de Not., *R.*, *M.*
Dasyscypha virginea (Batsch) Fuck., *A.*
Mollisia cinerea (Batsch) Karst., *M.*, *A.*
Stegia Ilicis Fr., *M.*, *Rf.*
Rhytisma acerinum (Pers.) Fr., *R.*, *Rf.*

PHYCOMYCETES.

Bremia Lactucae Regel, *R.*
Peronospora sordida Berk., on *Scrophularia*, *R.*
Syzygites megalocarpus Ehrenb., *R.*

PROTOMYCETACEAE.

Protomyces inundatus Dang., on *Apium nodiflorum*, *R.*

DEUTEROMYCETES.

Phyllosticta hedericola Dur. & Mont., *R.*, *M.*, *Rf.*
Phomopsis conorum (Sacc.) Died., *Rf.*
Actinonema Rosae (Lib.) Fr., *M.*
Septoria Rubi West., *R.*, *M.*, Violae West., *R.*, *M.*
Cytospora chrysosperma (Pers.) Fr., *Rf.*
Colletotrichum Lysimachiae Duke, *R.*
Libertella faginea Desm., *R.*, *A.*
Monilia aurea Gmel., *M.*
Oidium alphitoides Griff. & Maubl., *Rf.*, Euonymi-japonicae (Arcang.) Sacc., *R.*
Trichoderma viride (Pers.) Fr., *A.*
Botrytis cinerea Pers., *R.*
Rhinotrichum Thwaitesii B. & Br., *Rf.*
Ramularia lactea (Desm.) Sacc., *M.*, *A.*, Primulae Thuem., *R.*, *M.*, *Rf.*, calcea (Desm.) Ces., *R.*, *M.*, *Rf.*, *A.*, montana Speg., *R.*, Ajugae (Niessl.) Sacc., *R.*, acris Lindr., *Rf.*, Urticae Ces., *A.*
Bispora monilioides Corda, *R.*
Fusicladium dendriticum (Wallr.) Fuck., *M.*
Heterosporium gracile Sacc., *M.*
Cercospora Mercurialis Pass., *R.*, *M.*, *Rf.*
Isaria umbrina Pers., *R.*

SUSSEX LICHENS.

By H. H. Knight, M.A.

Except perhaps in the family Collemaceae, of which no species occurs on our list, the dry weather of the autumn of 1928 had no detrimental effect on the lichens, as it had on many of the larger fungi. The woods in the neighbourhood of Arundel consist mainly of beech with some ash and other trees. Among the lichens found on beech was *Pertusaria pustulata*. The hollies in

these woods were disappointing, but the elders were more productive, especially in species of *Bacidia*. At Michel Grove some elms yielded *Gyalecta Flotovii* and *Bacidia incompta*. As usual in the south of England, the Graphidaceae were well represented in contrast to Aviemore last year, where we found not a single species of this family. The two species of the genus *Stenocybe*, which appear first on the list, were looked for in the Arundel district, but we failed to find them there. *S. septata* was found on holly at Eridge rocks, and *S. byssacea* on alder near Graffham.

In compiling this list I have received much help from Miss Lorrain Smith and Mr Paulson.

R. = Rewell Wood; *M.* = Michel Grove; *E.* = Eartham Wood; *A.* = Arundel Park.

Stenocybe septata Rehm
S. byssacea Nyl.
Placynthium nigrum S. F. Gray, *R.*
Peltigera canina Willd.
Parmelia physodes Ach.
P. perlata Ach., *M.*
P. caperata Ach.
P. scortea Ach., *M.*
P. saxatilis Ach.
P. sulcata Tayl.
P. laevigata Ach., *R.*
P. revoluta Floerke, *R.*
P. fuliginosa Nyl. var. laetevirens Nyl.
Evernia prunastri Ach.
Ramalina calicaris Fr., *R.*
R. fastigiata Ach., *M.*
R. farinacea Ach.
R. pollinaria Ach., *M.*
Usnea florida Web. var. hirta Ach.
Xanthoria parietina Th. Fr.
X. polycarpa Oliv.
Placodium flavescens A. L. Sm.
P. murorum DC.
P. luteo-album Hepp., *M.*
Candelariella vitellina Muell.-Arg.
Physcia ciliaris DC., *M.*
P. pulverulenta Nyl., *M.*
and var. subpapillosa Cromb., *M.*
P. grisea A. Zahlbr., *E.*
P. hispida Tuckerm.
P. caesia Nyl., *R.*
P. orbicularis Dalle Torre & Sarnth. var. virella Dalla Torre & Sarnth., *M.*
Lecanora muralis Schaer.
L. subfusca Ach.
and var. allophana Ach.
L. rugosa Nyl.
L. campestris B. de Lesd.
L. pallida Schaer.
L. galactina Ach.
L. varia Ach.
L. symmictera Nyl. *M.*
L. parella Ach.
Lecania syringea Th. Fr., *R.*
Pertusaria globulifera Nyl., *M.*
P. faginea Leight.
P. multipuncta Nyl., *R.*, *M.*
P. pustulata Nyl., *R.*
P. pertusa Dal. Tor. & Sarnth.
P. coccodes Nyl., *A.*
P. leioplaca Schaer., *R.*
P. Wulfenii DC.
Diploschistes scruposus Norm., *R.*, *A.*
Cladonia sylvatica Hoffm., *R.*
C. fimbriata Fr.
C. furcata Schrad.
C. rangiformis Hoffm.
C. squamosa Hoffm.
C. macilenta Hoffm., *A.*
Gyalecta Flotovii Koerb., *M.*
Lecidea quernea Ach., *A.*
L. coarctata Nyl., *M.*
L. viridescens Ach., *R.*
L. atrofusca Nyl., *A.*
L. turgidula Fée, *A.*
L. mutabilis Fr., *A.*
L. parasema Ach.
and var. elaeochroma Ach.
Biatorina cyrtella Th. Fr.
B. Griffithii Massal., *M.*
B. erysiboides Th. Fr., *A.*
Bilimbia aromatica Jatta, *R.*
B. sabuletorum Br. & Rostr., *M.*
B. luteola Mudd, *M.*
B. effusa Arn., *R.*
B. Beckhausii Koerb., *R.*
B. atrogrisea Arn., *R.*
B. incompta Auzi, *M.*
Buellia canescens de Not.
B. myriocarpa Mudd
Rhizocarpon petraeum Massal.
R. confervoides DC.
Arthonia lurida Ach., *R.*
A. radiata Ach.
Opegrapha herpetica Ach., *R.*
O. atra Pers., *R.*

O. betulina Sm., *M.*
O. varia Pers., *M.*
O. vulgata Ach., *M.*
Graphis elegans Ach.
G. scripta Ach.
Phaeographis dendritica Muell.-Arg., *R.*, *M.*
Graphina anguina Muell.-Arg., *R.*
Enterographa crassa Fée, *R.*
Verrucaria viridula Ach., *A.*
V. nigrescens Pers.
V. rupestris Schrad., *R.*
V. dolomitica Massal., *A.*
Acrocordia gemmata Koerb., *M.*
A. biformis Oliv., *M.*
A. Salweii A. L. Sm., *A.*
Arthopyrenia epidermidis Mudd, *R.*
A. fallax Arn., *R.*
Porina carpinea A. Zahlbr., *R.*
Pyrenula nitida Ach., *R.*

PRESIDENTIAL ADDRESS.

By H. C. I. Gwynne-Vaughan, D.B.E., LL.D., D.Sc., F.L.S

PROBLEMS OF DEVELOPMENT IN THE FUNGI.

The common ground of the members of the British Mycological Society is their preoccupation with fungi, but the hand of the dyer is subdued to that he dyes in, and mycologists, like the fungi themselves, assume a most diverse variety of forms. There are those whose primary objective, in strict accordance with our motto, *Recognosce notum, ignotum inspice*, is to identify known forms and examine the new; there are pathologists whose aspiration is to do away with fungi, or at any rate with parasites, altogether; there are physiologists who grow fungi under new and unnatural conditions and make havoc of species in their progress; and there are the so-called academic mycologists, who scarcely recognise a fungus till they see it under the microscope.

I belong to the last, and, I fear, least acceptable category, and I have been puzzled to know what aspects of my rather specialised study are likely to be of interest to my fellow-members. Since, however, the fungi are themselves our common ground, it has occurred to me to consider the position of this great group and its relation to other living organisms.

First, then, we find that the fungi have, in common with green plants and animals, a number of significant characters. Their cell, and especially their nuclear structure, is similar; their method of nuclear division is the same, the nuclear material dividing into a number of chromosomes, which is constant for the species, and being distributed with meticulous equality to two daughter nuclei. More striking still, the number of chromosomes is doubled at some stage of the life history by a fertilisation process in which two nuclei fuse, and is halved again, in preparation for the next fertilisation, by a complicated meiotic division. Closely associated with the correspondence of fertilisation and meiosis is the correspondence of the method of transmission of hereditary characters. I need not remind you of the great mass of work on this subject among higher plants and

animals which has been carried out by Bateson and many others, or of the painstaking work of Hanna which has demonstrated a precisely similar method of inheritance in the Hymenomycetes. There is a great deal of variation in detail in the nuclear processes of different species, but none which distinguishes all animals from all plants, or either from all fungi.

The inference from these facts is obvious; the nuclear and genetic arrangements in question must have been present in a common ancestor before the separation of these great groups. It is difficult to imagine adjustments so delicate and exact as those of karyokinesis, syngamy and meiosis having originated independently along a number of lines. They are not universal; the Bacteria, the Blue-green Algae and some of the Protozoa lack organised nuclei or any form of fertilisation, and it was suggested long ago that they might be regarded as the remnants of an earlier type of life, preceding the evolution of nuclear structure.

Assuming, for these reasons, the common origin of animals, fungi and green plants, it falls next to consider the point or points of divergence of the group which forms our particular study. In the primitive members of each of the three series fertilisation is by the union of motile, uninucleate cells. This stage can still be observed among the fungi in *Synchytrium* and *Olpidium*. In animals a period of growth and development follows the union of the gametes, so that during the whole of active life the nucleus possesses the double number of chromosomes, and reduction, or meiosis, only takes place in the formation of the next crop of gametes. It is possible that the greater motility and greater metabolic activity of animals may be associated with their richer nuclear content.

In the simplest green plants fertilisation is commonly the signal for a period of rest, and often seems to be induced by conditions which demand the appearance of a resting cell. Moreover, the reduction in the chromosome number usually takes place in the first nuclear divisions when activity is resumed, so that during the whole vegetative period the cells have only x chromosomes in their nuclei, instead of $2x$ like animal cells. Apparently this is not a satisfactory condition, for we find a vegetative phase in which the number of chromosomes is $2x$ interpolated in the life history, so that an alternation of generations is established. At first the sporophyte is dependent throughout its growth on the parent gametophyte, but later, as in flowering plants, it becomes the dominant phase and provides the gametophyte with protection and food.

In this respect the fungi are nearer to green plants than they are to animals, for there is evidence that reduction immediately

follows fertilisation in many of the Phycomycetes and also in yeasts and their allies, while a well-marked alternation of generations is present in the higher Ascomycetes. Here we have evidence of the origin of the sporophyte, for spore formation, with which reduction is associated, takes place immediately after fertilisation in *Eremascus albus* and *Endomyces fibuliger*, while in *Endomyces Lindneri* a brief vegetative stage intervenes. This is the first appearance of the ascogenous hyphae which constitute the sporophytic phase of the Discomycetes and Pyrenomycetes. They are always dependent on the gametophyte for food and water, and culminate in the production of ascospores, in the course of formation of which chromosome reduction is accomplished. The conidia, which are the commonest means of multiplication in many of these fungi, are accessory spores of the gametophyte and play no part in the alternation of generations.

In the smuts reduction takes place in the germination of the brand spore and is followed by the appearance of the basidiospores. As is well known, the basidiospores, or cells developed from them, unite in pairs and their nuclei become associated but do not fuse; right up to the formation of the brand spores the mycelium consists of binucleate cells, and nuclear fusion takes place only in preparation for reduction. Delayed fusion of the gametic nuclei is not unknown among animals; in *Amoeba diploidea* the sexual nuclei do not unite until the next generation of gametes is about to be formed, and in many embryos fusion is postponed until several conjugate divisions have occurred. I hope to return later to the significance of this condition in Basidiomycetes; at present we are concerned with the fact that a vegetating gametophyte is present in this group.

The rusts, like the smuts, have successively a mycelium of uninucleate cells, and one in which the cells contain two nuclei. On the former are borne the spermogonia and aecidia, on the latter the uredo- and teleutospores; nuclear fusion takes place in the teleutospore cell, and reduction is brought about in the two divisions which precede the formation of the basidiospores, so that these each contain one nucleus; it is at the base of the aecidium that nuclei become associated either by the breaking down of the wall between two basal cells or by the entry of a vegetative nucleus into each of these. As a result the aecidiospore contains two nuclei.

Among the members of the great assemblage of Autobasidiomycetes, as among the smuts and rusts, the basidiospore contains a single nucleus. If we examine the gills, however, we find their cells to be binucleate; fusion of the two nuclei occurs in each young basidium and is followed by reduction. As might

be expected in so large a group, there is a great deal of variation about the stage at which the binucleate condition first appears. In *Psalliota campestris* the cells of the pileus and stem are multinucleate, binucleate cells occurring first in the trama; in *Boletus granulatus* the stipe is made up of multinucleate cells, but those of the ring and pileus each contain two nuclei; in species of *Coprinus* and *Panaeolus* the whole sporophore is built of binucleate cells. In these and other forms, moreover, the germ tube always gives rise to a mycelium of uninucleate cells, and the binucleate condition, in *Coprinus fimetarius* and many others, is attained by the fusion of two independent mycelia, closely corresponding to the fusion of basidiospores or their products in smuts.

The fungi have, then, in common with green plants, a vegetating gametophytic phase which animals do not possess. Alternation of two vegetating generations is also found among the higher members of each series, but, as neither the lower algae nor the simpler Phycomycetes show this adjustment, it cannot be claimed as evidence of a common origin unless we regard the fungi as polyphyletic, the individual families or alliances having arisen separately from the algae.

We are all familiar with the text-book suggestion that the Mucorales are related to *Spirogyra* and its allies, but only the briefest comparison of the vegetative and reproductive structure is necessary to assure us of the lack of evidence. A better case can be made for the parallelism of *Vaucheria* and *Saprolegnia*, but the differences both in accessory and sexual reproduction are very marked. I suppose we have all, at one time or another, been attracted by the ingenious hypothesis which derives the Ascomycetes and Red Algae from a common ancestor, but it is a discouraging fact that the resemblances are most marked between the more complicated, not between the simpler members of these groups.

Yet, even if we cannot point to particular algae as their precursors, we may still regard each of the great fungal alliances as having a separate origin. What, then, are the characters that they have in common, and to what extent are they distinguished by these from other organisms? The first and most striking of such characters is probably the mycelium. It is not of universal occurrence; we can trace its origin among the Archimycetes, where two factors, the search for food and the elaboration of a mechanism for spore dispersal have resulted in extensions of the original body which was wholly used up in reproduction. Septation of the mycelium is comparatively rare among Phycomycetes, and the septa are commonly far apart; in the higher fungi, where septation is the rule, the cells may be multinucleate

or uninucleate, both types sometimes occurring in the same plant, or the binucleate condition already referred to may supervene. There is no definite line of demarcation between the phycomycetous mycelium and that of the higher fungi.

We have already seen that the simplest fungi resemble primitive animals and algae in possessing motile cells which fuse in pairs. In animals the union of free, uninucleate gametes, only one of which is motile, is established early, and is retained throughout evolutionary history. Among the Green Algae numerous experiments are found in the fusion of free-swimming cells. These experiments culminate in the retention of the egg in an oogonium and the entrance of a motile sperm, while, in higher plants, motility disappears, and the male nucleus is carried by a pollen tube to the female.

Very early in the development of the fungi, on the other hand, the production of motile gametes is abandoned, and union takes place, not between individual cells, but between the organs of reproduction, two undifferentiated gametangia, or gametangia differentiated to form an antheridium and oogonium. In *Olpidiopsis* the body consists of a single multinucleate protoplast, surrounded by a delicate wall. Two such structures of different size, if side by side in the same host cell, may fuse, the contents of the smaller passing into the larger. In *Zygorhizidium* the distance between two fusing individuals is bridged by a conjugating tube put out by the smaller. In *Polyphagus* the individuals are uninucleate; here again the conjugation tube is put out by the smaller cell, but the contents of this cell do not pass beyond the end of the tube, where they are joined by those of the larger participant; accordingly the same cell is responsible for the conjugation tube along which its contents move and for the wall of the zygote.

Throughout the fungi gametes are rare, and fertilisation consists of the union of gametangia as a whole. This renders useless our usual criteria of sexual differentiation. The male gamete is defined as smaller and more active, the female as larger and stored with food, but there is nothing in our experience of green plants to justify the assumption that the antheridium need differ from the oogonium either in size or activity. Two criteria remain, the superior activity, not of the antheridium but of its contents, corresponding to the activity of the male cells in green plants, and the production of the zygote wall, always a function of the female cell or its environment. Bearing these criteria in mind, we may recognise the smaller cell of *Olpidiopsis* or *Zygorhizidium* as antheridial and may apply the same reasoning to the sexual apparatus of the higher fungi; *Polyphagus* may be regarded as still in the experimental stage, suggesting that the differentiation

of male and female organs has taken place within the limits of the fungi. It is interesting to note that the production of gametangia is definitely a plant character, and is conditioned by the presence of a vegetating gametophyte. In animals, where the formation of gametes is associated with the reduction division, no comparable structure appears.

In the Oomycetes the contents of the female organ may form a single multinucleate mass, into which numerous antheridial nuclei enter, or only one female nucleus may be selected while the others disintegrate, or several uninucleate masses may be formed, as in *Saprolegnia*, and each be separately fertilised. In every case the conjugation tube is antheridial. In most of the Zygomycetes, on the other hand, there is no structural difference between the large, multinucleate gametangia. They develop where two mycelial branches meet, and, on attaining their full size, flow into one another, their nuclei fusing in pairs. A zygospore is the immediate product of fertilisation and usually gives rise to a stalked sporangium.

The special interest of the method of reproduction in the Zygomycetes lies in the differentiation of the mycelium in *Mucor* and other species, where gametangia will develop only if mycelia of physiologically different strains make contact. Since the gametangia are similar in form and behaviour, it is impossible to describe one as male and the other as female, and the non-committal terms + and − have come into use. Heterothallic forms possess + and − mycelia; in homothallic species, like *Syzygites megalocarpus*, zygotes may be formed between branches of a single mycelium. Comparable heterothallic and homothallic conditions are found in *Spirogyra*, where, as in *Mucor*, the gametangia are alike, and borne on different filaments. In the homothallic genus *Zygorhynchus* the gametangia differ in size, and in *Syncephalis* they are distinguished also in form and behaviour. In the last-named genus, and in its allies, the zygote is a lateral outgrowth from the gametangium, while in *Mortierella* the zygote is surrounded by a mass of protective hyphae.

Already, then, within the limits of the Phycomycetes, the union of multinucleate gametangia has been established, various lines of sexual differentiation have been laid down, and provision for the protection of the zygote has been initiated.

Among Ascomycetes the type of sexual apparatus is closely comparable and offers evidence of a common origin; there is, however, a much greater range of variation, as might be expected in view of the very different size of the group, which comprises some 15,000 species, in contrast to the 800 species of Phycomycetes.

Another point which seems to indicate for the Ascomycetes

an origin among the lower fungi is the method of accessory multiplication. Zoospores may be regarded as the most ancient of all means of reproduction, representing, as they do, a return to the unicellular, free-swimming ancestor. The region in which they are developed undergoes progressive specialisation, forming a definite sporangium. Such sporangia are common among Phycomycetes, in aquatic and amphibious forms they still give rise to zoospores; in the Mucorales their spores are non-motile and provided with a wall. A very pretty reduction series can be traced in certain families of white moulds, whereby the sporangium comes at last to contain only one spore, and is then thrown off entire. In the Peronosporales the formation of zoospores is dependent on suitably moist conditions, in dry weather the contents of the sporangium are not differentiated, the sporangium falls off as a whole, and sends out a germ tube from which a fresh mycelium is developed; in *Cystopus* and its allies, the sporangia are borne in chains and are closely comparable with the conidia of *Sphaerotheca*, *Eurotium* or *Penicillium*.

In the Basidiomycetes, also, conidia are formed; they are not so frequent as among Ascomycetes, but seem to point to a common origin. Unfortunately little help can be obtained, in respect of this group, from the sexual apparatus, since, apart from the spermatia and basal cells of the aecidium in rusts, gametangia have wholly disappeared. Not a trace of such structures can be found either in the smuts or in the higher Basidiomycetes. The mycelium, however, is similar to that of the Ascomycetes, and shows the same tendency to fuse, either with its own branches, or with independent hyphae.

There is one point of resemblance between the Basidiomycetes and Ascomycetes so striking, if I interpret it correctly, that it cannot be ignored; this is the occurrence of a special type of heterothallism, not associated with the presence of sexual organs, and probably best defined as nutritive heterothallism.

The condition in question was, I believe, first observed by Egerton who, in 1914, described the existence in *Glomerella cingulata* of two distinct strains. One, designated as +, grows rapidly, develops white or light grey aerial hyphae, and produces a few perithecia which reach normal maturity. In the other, or −, strain aerial hyphae are scanty while perithecia are numerous, but asci do not ripen in culture except on acidified oat agar, and even then are irregular in form. Where the two strains meet, fertile perithecia are abundant. Moreover, the asci in a perithecium in a + or a − mycelium produce only corresponding spores, whereas those in perithecia along the line of junction of two strains have been shown to contain spores of both kinds. Since, in the growing ascus, only one nucleus is present from

which the nuclei of the eight spores are derived, it is evident that nuclear fusion must have brought together the characters of the two strains which are afterwards distributed to the spores.

Kniep, from 1915 onwards, and Bensaude, independently in 1918, described the occurrence of two strains in a number of Hymenomycetes. In *Coprinus fimetarius*, for example, the germinating basidiospore gives rise to a mycelium of uninucleate cells. This "primary" mycelium alone is incapable of forming sporophores but, if two primary mycelia of different strains are brought together, one + and one −, fusion takes place, a "secondary" mycelium of binucleate cells is developed, and abundant sporophores appear. As in the ascus of *Glomerella*, so in the basidium of *Coprinus*, nuclear fusion occurs and is followed by the distribution of the + and − characters to the four basidiospores. Not all the Hymenomycetes examined are heterothallic, in many of them a mycelium from a single spore can readily produce fruits; while, even among the heterothallic species, some will form sporophores in single spore culture after a few months' delay, which would have developed them quickly had two strains been present.

Kniep, Hanna and others have shown that in certain species four strains exist, denoted by *AB*, *Ab*, *aB* and *ab*, and that fruiting takes place when *AB* and *ab*, or *Ab* and *aB* meet, so that the four characters *A*, *a*, *B* and *b* are present together.

The same type of heterothallism is found in several of the smuts, where two, three or four strains may occur, in the rusts, where Craigie has described two species of *Puccinia* as having two strains, and in *Penicillium luteum*, *Neurospora sitophila*, *Humaria granulata* and other Ascomycetes, where two strains have been recorded, and where Dodge, for *Neurospora*, has shown that segregation takes place in the divisions in the ascus.

Many of the workers in this field have regarded the difference between the strains, whether two, three or four in number, as a distinction of sex. In the Hymenomycetes, unfortunately, no sexual organs are found, and in only one of the heterothallic Ascomycetes has investigation so far extended to the initiation of the ascocarp. In this case, the apogamous *Humaria granulata* both + and − strains bear female organs, so that it is impossible to regard as sexual the difference between them. Some nutritive or other explanation must accordingly be sought, and will probably prove applicable to all cases where fusion is mycelial and not between gametangia.

For the moment, however, I am not concerned with the interpretation of these phenomena, but with the fact that they occur in both the great groups of higher fungi, and nowhere else in the plant or animal kingdoms. They form a strong indication of

common origin. In the Basidiomycetes the union of + and − strains is stated to bring two unrelated nuclei into association, but these do not fuse till, after many cell generations, the basidium has appeared. In the ascus, also, nuclear fusion takes place. Since the cells from which they come are multinucleate, it is difficult to trace the origin of the two nuclei in the young ascus, but recent work on *Neurospora sitophila* already indicates that they may be + and −. Here, again, is a striking correspondence. It is true that there are two nuclear divisions in the basidium and three in the ascus. Many observers have also recorded two nuclear fusions in the life history of Ascomycetes, describing the earlier fusion, which takes place in the gametangium, as the completion of a sexual act. Is it possible, then, that the delayed fusion in the ascus corresponds to the delayed fusion in the basidium of Hymenomycetes, a group in which gametangia have disappeared? Several minor problems will have to be solved before this can be definitely asserted.

Meanwhile it may be said that both morphological and cytological evidence points in an increasingly definite manner to the monophyletic character of the fungi, and to their origin either independently of other plants and animals, though from the same source, or very early in the evolution of the former. By what steps that evolution was initiated I will not be so rash as to suggest.

THE DEVELOPMENT IN CULTURE OF ASCOCHYTA GOSSYPII SYD.

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(With twenty-three Text-figures.)

Introduction.

Ascochyta Gossypii is a parasitic fungus occurring on the cultivated cotton plant.

The first description of the fungus was that of Sydow(15), based on material collected by Dr E. J. Butler at Kashmir in 1908, but subsequent appearances of the organism have been entirely confined to the cotton fields of the Southern United States. A serious outbreak of Ascochyta-blight took place in Arkansas during June, 1920, when, for the first time, the disease became of economic importance. Material sent into the Arkansas Experimental Station was examined by Elliott(6), who isolated and identified the causal organism. A detailed study of the

pathological effects and relations of the disease to environmental conditions was made, but comparatively little work was done on the morphology of the fungus and its behaviour on artificial media.

In more recent years, Ascochyta-disease has become much more common, and has extended its distribution over the South-Eastern States. The less serious form of the disease manifests itself in the field as a spotting of the petioles and leaves on the older parts of the plant, but under suitable conditions the fungus is capable of producing large lesions on all aerial parts.

In the present experiments, inoculations of the fungus into cotton plants growing under glass have been uniformly unsuccessful, and attention has been confined to the behaviour of the organism on artificial media, under laboratory conditions.

Methods.

The material used in the present work had as its origin a tube culture given to me by Professor Robinson of Aberystwyth University, who had isolated *Ascochyta Gossypii* from diseased cotton plants growing at Moyock, N. Carolina. The fungus was growing on asparagin agar, and had produced a fair number of pycnidia and chlamydospores. On account of the tube having already been opened, the culture was assumed to be impure, and the usual dilution method was followed for obtaining pure cultures. These were used in studying the development of the pycnidium as described later. Afterwards, about a dozen single-spore cultures were made by cutting out, under the microscope, germinated spores from agar-plates, and transferring them to agar slants in tubes. These single-spore colonies agreed in all respects with the pure cultures already obtained; they were used in the physiological experiments which were performed later.

For observing the development of the pycnidia, it was found desirable to have cultures in which the fruit bodies could be seen without difficulty under the microscope, and also macroscopically. A modified Coons' agar was found to be a suitable medium, the fungus producing fairly numerous pycnidia, only slightly sunk in the agar, and, on account of the small amount of aerial mycelium, readily visible. The following is the composition of this medium:

Ammonium nitrate—*M*/2000.
Potassium dihydrogen phosphate—*M*/500.
Magnesium sulphate—*M*/500.
Maltose—*M*/500.
Agar agar—two per cent.
Ferric chloride—a trace.

Sterilisation was effected by autoclaving for twenty minutes at 120° C.

This medium was employed by Robinson in his work on *Pyronema confluens* (14). It is referred to below as "synthetic agar".

The earliest stages of pycnidial development were studied in material grown on thin films of the agar on microscope slides. These were fixed and stained *in situ*, but the developing primordia soon became too opaque for detailed examination, and sectioning was employed, blocks of agar bearing primordia or pycnidia being imbedded in paraffin, and sectioned at 2μ and 5μ. Supplementary observations were also made on material from five per cent. malt agar, on which medium vigorous vegetative growth occurred. In staining, a trial was made of several different reagents, but by far the best results were given by Haidenhain's haematoxylin and a two per cent. aqueous solution of Bismarck brown. The former was used as a protoplasmic stain, little destaining being done; the Bismarck brown stained hyphal walls well and had the further advantage of differentiating mucilage.

All drawings have been made with the aid of a camera lucida, but it was sometimes found necessary to draw the finer details in freehand.

Life history on various media.

On the modified Coons' agar, the fungus produces few aerial hyphae, but a hyaline mycelium is rapidly developed, which adheres closely to the surface of the substratum, and penetrates into it to a considerable depth. At temperatures of 20° C. or over, discrete pycnidia are produced, thirty-six hours after sowing the spores, and chlamydospores on or after the fifth day. The last are spherical, with a smooth, fairly thick wall; they are dark brown, and are produced both singly and in chains of up to five spores together (see Fig. 1). They are rather variable in size, measuring from 10 to 18μ; several large oil globules constitute the food reserve.

Under certain conditions on this medium, large, catenulate, *Alternaria*-like spores are formed (see Fig. 2). These spores (which for convenience will be referred to as "hypnocysts") are very dark brown, with undifferentiated contents, and extremely thick walls; they are variable in size, but $39\mu \times 17\mu$ may be taken as representative figures. The developing hypnocysts are usually produced at the ends of lateral, aerial branches (Fig. 3), and are at first club-shaped, colourless, and aseptate; later, walls are laid down in all three planes, and a great deal of pigment is gradually developed. Growth may continue at the apex of the spore; these cells, also, being at first colourless, but finally resembling those first formed, and in this way the catenulation, mentioned above, is produced. This new growth may

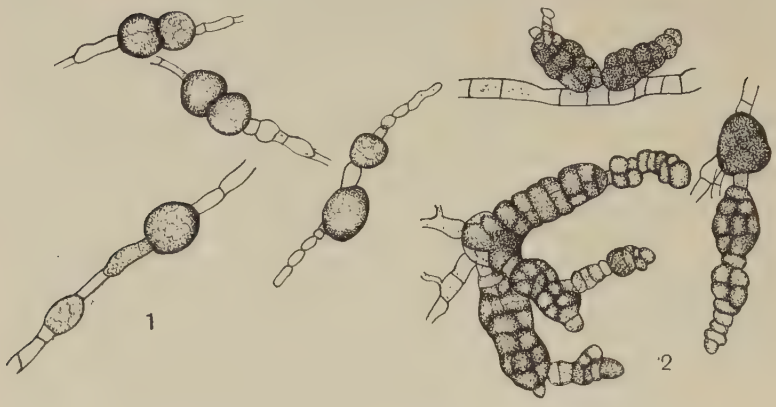

Fig. 1. Chlamydospores in optical section, showing oil globules. × 400.
Fig. 2. Mature hypnocysts with catenulation and branching. ×400.

Fig. 3. Young developing hypnocysts. × 400.
Fig. 4. Germinating hypnocysts drawn from fresh material. × 400.

take place, also, at the base of the spore, in which case the twin or triple spores, seen in Figs. 2 and 3, are obtained. The conidiophore itself finally becomes dark coloured, and may divide into very short swollen cells. In germination (see Fig. 4) long, aseptate hyphae, which for a considerable distance are unbranched, emerge either directly from the spore, or from a colourless vesicle which has protruded earlier.

The resultant colonies possess several marked peculiarities, distinguishing them from those developing from pycnospores; the majority of the pycnidia are smaller, the mycelium develops more pigment, and there is an earlier and more abundant reproduction of the parent spore form; moreover, the colonies arising from the resulting pycnospores share these characteristics. So pronounced are these differences that at first it was believed that the hypnocysts in cultures of *Ascochyta* represented an impurity. It was found, however, that the differences between what appeared to be two organisms were of degree rather than of kind, and all were liable to vary. Moreover, hypnocysts have been repeatedly produced on cultures of *Ascochyta Gossypii* arising from single pycnospores, and sometimes colonies growing from hypnocysts have had none of the above peculiarities. It is believed, therefore, that these spores form part of the life cycle of *Ascochyta Gossypii*.

On five per cent. malt extract agar, vigorous vegetative growth takes place, the hyphae being profusely branched, and often forming united strands. Although a marked zonation is frequent for the first three or four days, this is later obscured, a uniform grey felt covering the agar. Beneath this stratum the very short and copious branching of the hyphae which lie on and penetrate into the medium, causes the formation of a thick coherent mat, which gives a characteristic black appearance to the culture. The production of pycnidia is extremely capricious, but much of the variation is explained by the alteration of the medium during sterilisation. Chlamydospores are formed in large numbers, but hypnocysts only sparingly.

Growing on potato agar, *Ascochyta Gossypii* forms very light grey, flocculent colonies, with no zonation; there is an abundant formation of chlamydospores, which causes the colony to assume a dark colour and involves the collapse of the aerial hyphae, but the production of pycnidia is uncertain.

As already noticed by Elliott, on beef-peptone agar few or no pycnidia are produced, but removal of the mycelium to a carbohydrate medium causes their immediate formation. The development of chlamydospores is greatly delayed, and they have very little pigment, and no oil. Few aerial hyphae are produced, and the mycelium is glistening and colourless.

In liquid media containing different proportions of maltose or glucose, potassium dihydrogen phosphate, magnesium sulphate, and ammonium nitrate, a copious mycelium is developed, but the production of pycnidia is adversely affected, so that the growth cannot be regarded as normal.

It has been found that the nutritional requirements of the fungus are small in the extreme. Considerable growth, with the production of a fair number of pycnidia and chlamydospores, takes place on washed agar and distilled water alone. Indeed, the accidental impurities present in distilled water provide sufficient nutriment for growth and reproduction, since cultures made in glass capsules containing only distilled water have developed considerable mycelium with chlamydospores and a very few pycnidia.

Figs. 5–10. Very early stages in pycnidial formation. × 775.

The above description of the development of the fungus on different media is based on cultures grown in a closed incubator at 20° C.

It may be mentioned that, although attention has been paid to the possibility of heterothallism within the organism, no indication of anything in the nature of that phenomenon has been obtained.

Development and structure of the pycnidium.

In studying the development of the pycnidium in a number of fungi, de Bary (2) made a distinction between meristogenous and symphyogenous development; in the former the pycnidium arose from the segmentation of several cells of a single hypha into a parenchymatous mass, and in the latter a tangle of hyphae, which entwined themselves into a close knot, formed the primordium. Kempton (9) investigated from this point of view a large number of species and found many variations, in detail, of these two modes of origin. That of commonest occurrence was where two or more hyphae segmented and fused to form one primordium; this he referred to as "compound meristogenous" development.

Dodge (5) has made a detailed study of the formation of the cavity in pycnidia occurring on fruit. In *Phyllosticta carpogena* the central cavity was formed by the lysigenetic disorganisation of the inner cells of the pycnosclerotium, whereas in *Schizoparme straminea* the formation was schizogenetic, the inner tissue of the primordium being broken, on account of the greater growth of the periphery.

In many species of the Sphaeropsidales the exact manner in which the spores are produced is exceedingly difficult to make out, and has given rise to some difference of opinion. Von Hoehnel (8) considers that in some genera, spore formation takes place by the histolysis of the central cells, within which the spores are formed, or which are transformed into spores themselves. Such forms he terms sclerophominous, but his work has been both refuted (van Luyk (12), Archer (1)) and confirmed (Petrak (13)).

The different species of *Ascochyta* show no uniformity of method in the development of pycnospores, sterigmata being present in some forms (von Hoehnel (8), Harter (7)) and absent in others (Archer (1)). The present species of *Ascochyta* belongs to the latter class.

In cultures of *Ascochyta Gossypii* on the synthetic medium mentioned above, certain hyphae are more prominent than the rest of the mycelium, due to their being broader, having more frequent septa, and to their continuing unbranched for a considerable part of the colony. The pycnidia arise chiefly along these hyphae, and as their production continues for some time,

Fig. 11. Section of a very young primordium, showing an undifferentiated mass of cells.
Fig. 12. Primordium in which differentiation into sclerosed wall cells, cells with dense contents and spores, is complete.
Fig. 13. Pycnidium showing stage in formation of ostiolar cavity consequent on Fig. 18.
Fig. 14. Mature pycnidium, with central mass of spores surrounded by densely stained flattened cells (cf. Fig. 22).
Figs. 11–14. All × 775.

primordia at different stages of development are present with mature pycnidia.

Fig. 15. Section of a primordium in which histolysis of the central cells and sclerosis of the outer cell walls have commenced.
Fig. 16. Advanced primordium with cavity containing spores, mucilage and a few unchanged cells (cf. Fig. 19).
Fig. 17. More advanced stage than Fig. 12, showing commencement of dissolution of tissue at base of ostiolar column.
Fig. 18. Pycnidium in which formation of ostiolar cavity has commenced.
Figs. 15–18. All × 775.

One to four cells of the fertile hypha increase considerably in size, and are marked out by their denser protoplasm (Figs. 5

and 6); in these cells, divisions in various planes occur, and a knot of parenchymatous tissue is formed (*e.g.* Figs. 6–10). That is, the pycnidium, in the terminology of Kempton and de Bary, has a "simple meristogenous" origin. Occasionally, the origin is "compound meristogenous," two or, rarely, more hyphae undergoing division, and uniting to form one primordium (Fig. 10). As the primordium grows, the peripheral cells bud out hyphae which may fuse with the neighbouring vegetative ones, and branches from the latter also unite with the gnarl, so that it comes to be surrounded with a halo of radiating hyphae (*e.g.* in Figs. 10 and 23). It seems probable that these hyphae assist in the supply of food material to the developing pycnidium, and their extremities constitute a considerable portion of its periphery (see for example Figs. 12 and 16).

Sections of the young primordia showed them to consist of an undifferentiated group of cells (Fig. 11), the first change taking place at the centre where the cell walls become mucilaginous. This histolysis also destroys some of the cells themselves, but it is thought that a few persist and later give rise to spores by division. It is in this lysigenetic manner that the cavity of the pycnidium is formed (Figs. 15 and 16). A differentiation now takes place among the peripheral cells, those immediately surrounding the cavity having dense contents and indistinct walls, and the exterior cells staining faintly with the haematoxylin and having their walls sclerosed. The former give rise to the spores, but the exact method of production is difficult to make out. Several cases of budding off of spores from these cells have, however, been observed (see Figs. 19, 20 and 21), and as the pycnospores immediately adjoining them are, usually, radially orientated, there can be little doubt that sporulation occurs in this way.

The position of the ostiole is marked by a cylinder of densely stained cells which have undergone neither of the above changes, but when the pycnidium has completed about three-fourths of its development, the lower and central cells begin to break down, and are transformed into mucilage (*e.g.* Figs. 17 and 18). This histolysis of the central cells advances upwards, but a densely staining layer of cells, interior to the sclerosed wall cells, remains, and by the extension of these layers a short papilla is formed; finally, the ostiole becomes open to the exterior.

The increase in size of the interior of the pycnidium causes a displacement of the thick-walled outer cells, and these ultimately form a layer, which almost invariably is only one cell thick. Within this comes a single layer of flattened cells, with dense contents, and the interior is packed with spores embedded in mucilage (Figs. 14 and 22). It will be seen from the figures that

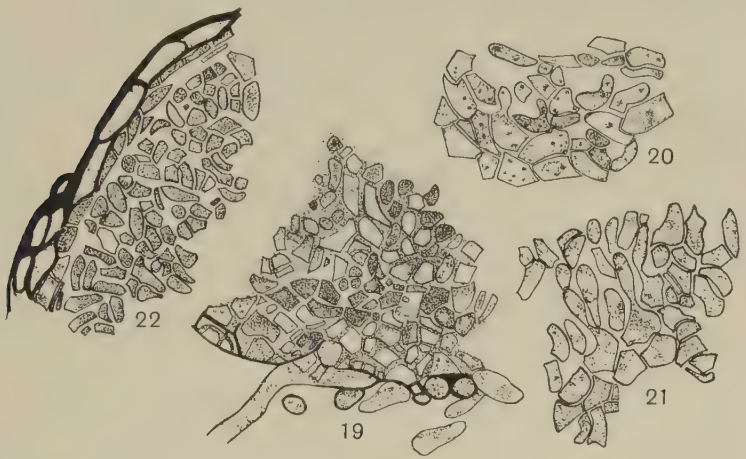

Fig. 19. Portion of the primordium represented in Fig. 16 showing the cell contents.
Figs. 20 and 21. Central cells of primordia, from some of which spores are being budded off.
Fig. 22. Portion of the pycnidium illustrated in Fig. 14 with cell contents shown.
Figs. 19–22. All × 1030.

Fig. 23. Pycnidia liberating coils of spores into water. × 120.

the size of a pycnidium is no criterion of its age, but it must be stated that the pycnidium enlarges continuously up to maturity.

The mature pycnidium is greyish brown, measures 70 to 200 μ in diameter, and has one or more ostioles 19 to 42 μ in diameter; several pycnidia are frequently found fused, their cavities being continuous. The pycnospores measure about $5{\cdot}7 \times 3\,\mu$ and are generally aseptate; the highest percentage of septate spores found in any collection was twenty per cent., and in most samples very few indeed were present.

In Fig. 23 are shown mature pycnidia liberating into water long coils of mucilage with the embedded pycnospores. The difference in size that exists between pycnidia is also made evident.

Behaviour towards physical factors.

The synthetic agar was employed in studies on the effects of physical factors, but unfortunately, owing to the peculiarities of the fungus, it was not found possible to develop a satisfactory technique for exact nutritional studies.

In all the experiments, the Petri dishes or test-tubes, in which the fungus was grown, were thoroughly cleaned by immersion overnight in a mixture of sulphuric acid and potassium bichromate, followed by repeated washing. Throughout the work, the same single-spore strain was employed, and the inoculum was always a suspension of pycnospores which had been passed through a sterilised filter paper.

Light.

Previous workers (Coons (3, 4); Leonian (10); Levin (11)), have found that the majority of the Sphaeropsidales are dependent on light for pycnidial production, but the present organism was early seen to diverge from this rule. Cultures of the fungus have produced abundant pycnidia when growing in complete darkness, and this result has been repeatedly confirmed in later experiments. Chlamydospores and hypnocysts are likewise produced, both in complete darkness and in the light, and no effect of the latter on the habit of mycelial growth has been observed.

Temperature.

In studying the effect of temperature on the fungus, plate cultures have been grown in closed incubators at 33° C., 23° C. and 20° C., but for temperatures lower than these dependence has been placed on cultures grown in the open laboratory and in a closed cupboard outside.

The organism has been found to be extremely sensitive to changes in temperature. At temperatures round about 10° C., growth is slow, but pycnidia and hypnocysts are produced in small numbers. Chlamydospores are, however, completely absent from most colonies, and very few indeed have been seen on cultures at this temperature. Removal to a higher temperature causes their formation at once (*e.g.* within forty-eight hours at 23° C.). At 20° C. all three spore forms are produced, but the formation of hypnocysts is erratic, and there can be no doubt that a low temperature induces their production, though naturally the time of their appearance is delayed. Colonies growing at about 10° C. have repeatedly developed hypnocysts, whereas on the control cultures at 23° C. they have been entirely wanting.

A temperature of 33° C. is sufficient to retard growth and pycnidial development, but an abundant production of chlamydospores and pigment takes place. In these facts, and in the appearance of the chlamydospores and hypnocysts (cf. Figs. 1 and 2) there is a strong suggestion that these spores are analogous structures, temperature being the factor that determines which of them shall be developed by the organism.

Aeration.

Preliminary observations on the relation of the fungus to aeration, having yielded inconclusive results, the following simple experiment was set up. Cultures were made on agar slants in test tubes, the cottonwool plugs pushed down the tubes, and the latter filled up with paraffin wax. Considerably fewer pycnidia were developed, but the production of chlamydospores was undiminished. In cultures, however, in which the plugs were pushed lower into the tubes, thus diminishing the volume of air still further, it was found that pycnidial formation was completely inhibited, and the development of the mycelium and of the chlamydospores was also adversely affected in a small degree. The small amount of pigment developed in the pycnidia and chlamydospores was also a marked feature of these sealed cultures.

The experiment was repeated, and a control series also set up, in which the tubes had their plugs moistened with 1 c.c. of a ten per cent. solution of caustic soda, previous to being sealed. In all of these, abundant pycnidia were produced, suggesting that the reduction in the first case was due to the accumulation of carbon dioxide, and not to an insufficiency of oxygen. It should be noticed, however, that in these experiments, the influence of humidity, and effects due to differences in that factor, are not eliminated; experiments with plate cultures grown in atmospheres containing high percentages (about 30%)

of carbon dioxide, have, however, yielded similar results to those from sealed tube-cultures. It is clear, therefore, that the oxygen requirements of the organism are exceedingly small, but there is a marked susceptibility to the presence of carbon dioxide.

Summary.

1. The life history of *Ascochyta Gossypii*, growing on various media in the laboratory, has been described.

2. In addition to pycnidia, chlamydospores and resting cells ("hypnocysts") are developed by the organism.

3. The pycnidia arise by the segmentation of a small number of cells in one or more hyphae, a parenchymatous mass of tissue being formed.

4. Both the central and ostiolar cavities in the pycnidium are formed by a mucilaginous histolysis (*i.e.* the formation is lysigenetic).

5. The pycnospores are budded off from the cells surrounding the cavity.

6. The organism is independent of light in its development, but is very susceptible to changes in temperature, and excess of carbon dioxide is inimical to pycnidial formation.

In conclusion, I wish to express my indebtedness to Professor Lang for the help that he has given me throughout this work, and to Professor Robinson for his valuable advice and criticism. I also beg to thank Dr W. B. Grove for his kindness in confirming the identification of the fungus.

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THE FUNGUS CAUSING LEAF ROT OF THE CARNATION.

By W. Buddin and E. M. Wakefield.

(With three Text-figures.)

In the *Gardeners' Chronicle*, lxxxi (1927), 196 and 216, Professor Salmon and Mr W. M. Ware described a disease of border carnations to which they gave the name of Leaf Rot. The disease was apparently new to this country, but was found to be known in Holland and Germany. It is characterised by the presence on the leaves and stems of large, soft, greyish or brownish lesions, which bear numerous tiny raised pustules. The latter are the acervuli of an imperfect fungus belonging to the Hyphomycetes. Eventually the tissues attacked become completely rotted.

When observed in Holland (1) the fungus was described as being in habit somewhat like a *Gloeosporium*, but with spores which were two- or frequently three-celled. Hence the genera *Marssonina* and *Septogloeum* were mentioned as possibilities, but no definite determination was made. Meanwhile the fungus had already been described in Germany in a paper which was evidently not known to the Dutch pathologists. Höstermann and Laubert (2) gave in 1921 an excellent description of a "new fungus disease of the carnation," and, owing to the peculiar characters of the fungus, erected for it a new genus which they called *Pseudodiscosia*, the species being given the name of *P. Dianthi*.

When diseased material came into the hands of Professor Salmon early in 1927, the fungus was recognised by Dr Pethybridge as being probably identical with that described in the German paper. The present authors were given an opportunity of examining a specimen, and were much interested to find that the fungus resembled very closely, particularly in the form of the conidia, the non-pycnidial, parasitic stage of *Hcteropatella Antirrhini* (3), the cause of a destructive disease of cultivated antirrhinums. With their usual kindness, Professor Salmon and Mr Ware willingly provided material for comparison and cultural work.

It may be noted here that during the summer of 1927—a season particularly suited to this type of fungus on account of its low temperatures and heavy rainfall—the fungus was found by us to be present almost wherever sought for. Few border carnations were met with, but the fungus occurred commonly on various types of pinks, including "Mrs Sinkins," although apparently it never did any appreciable damage to these hardier forms of *Dianthus*.

The acervuli are minute, appearing as tiny raised pustules originating beneath the cuticle of the host plant. In dry weather

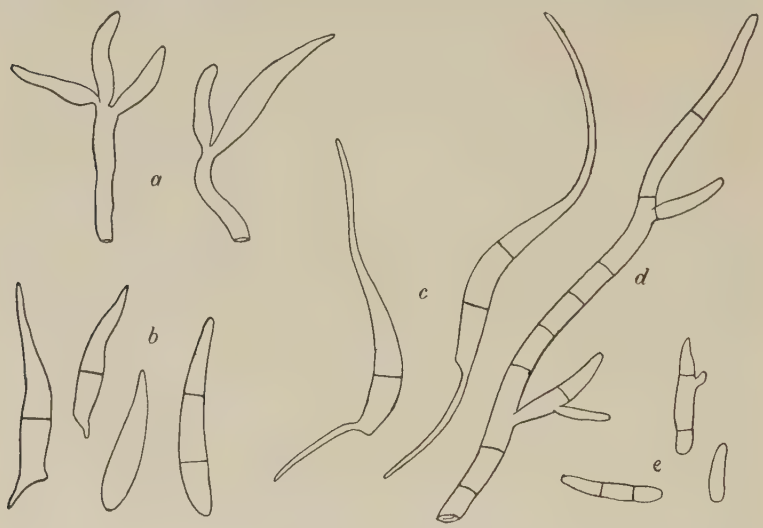

Fig. 1. *Heteropatella Dianthi*, parasitic stage. *a*. Conidiophores and young conidia. × 850. *b*. Conidia as frequently found, with appendages not fully developed. × 850. *c*. Conidia from culture of *Pseudodiscosia Dianthi* obtained from Baarn. × 850. *d*. Mycelium of *Pseudodiscosia* in pure culture. × 550. *e*. Conidia (primary form) found in cultures on malt agar, etc. × 550.

it may be difficult to find spores, and such as occur are short, and at most only one- or two-septate, with no appendages (Fig. 1, *b*). In damp weather, however, conidia are formed abundantly and their final form is similar to that of the mature conidia in *Heteropatella Antirrhini*, namely, two- to three-septate, with a very long-drawn-out apex and a more abruptly attached, pedicel-like basal appendage (Fig. 1, *c*). As compared with the conidia of the parasitic stage of *H. Antirrhini*, those of the carnation fungus are broader (average 5–6 μ) and the body portion is somewhat shorter (not more than 25 μ long). The appendages, however, vary so much in length, and are so frequently absent, that their measurements are worth little as a

diagnostic character. Under favourable conditions the apical portion may reach 25 or 30 μ in length, and the basal a little less. It is common to find that none of the tailed spores are developed, but only small conidia of extremely variable size with no, or only one, septum. These correspond to the "primary conidia" observed in growths from spores of *H. Antirrhini* ((3) p. 179), and occur also in cultures of the fungus under consideration (Fig. 1, *d*, *e*). Such conidia suggest the genus *Marssonina*, and it has been found that a specimen which was received at Kew in 1924 and referred to a form of *Marssonina Delastrei* was in reality this species.

Without question the fungus is the same as that described by Höstermann and Laubert (*loc. cit.*). These authors also mention the great variability of the spores and the frequent lack of appendages. In one point, however, our observations differ from the previous description. Höstermann and Laubert speak of the cells of the sporiferous layer acting as conidiophores: from their figure it would appear that they saw no differentiated conidiophores and regarded the spores as practically sessile on the basal tissue. As shown in Fig. 1, *a*, this is not the case. The conidiophores when teased out are cylindrical, 3–4 μ in diameter, and frequently branched. The point is of importance in considering

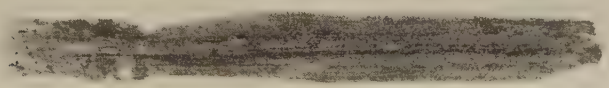

Fig. 2. Carnation Leaf showing pycnidia of *Heteropatella Dianthi* towards base. Nat. size.

the systematic position of the fungus. The German authors had evidently considered the resemblance in form between the conidia of their fungus and those of *Heteropatella*, for they remark: "*Heteropatella* differs in the swollen acervulus and branched conidiophores." The second character is not accurate: in point of fact there is no difference between the conidiophores of *Pseudodiscosia* and those of *Heteropatella*.

The original material received from Wye consisted of fairly large, old clumps of carnation, with numerous typical lesions on the green leaves. In addition, careful search on the lower, old and very rotten leaves, and on the lower portions of still living leaves revealed the presence of pycnidial fructifications of the *Heteropatella* type (Figs. 2, 3, *a*). These were similar in

shape to those of *H. Antirrhini*, but smaller, and without the *Geaster*-like arrangement of the apical lobes when open. The pycnidia were from 0·25 to 0·5 mm. in diameter, and the spores, when ripe, were extruded in dirty whitish globules. The conidia (Fig. 3, *c*) were of the characteristic form, and markedly curved, with long appendages. The size of the conidia was similar to that of the *Pseudodiscosia* form, namely, body 20–25 μ × 4–6 μ,

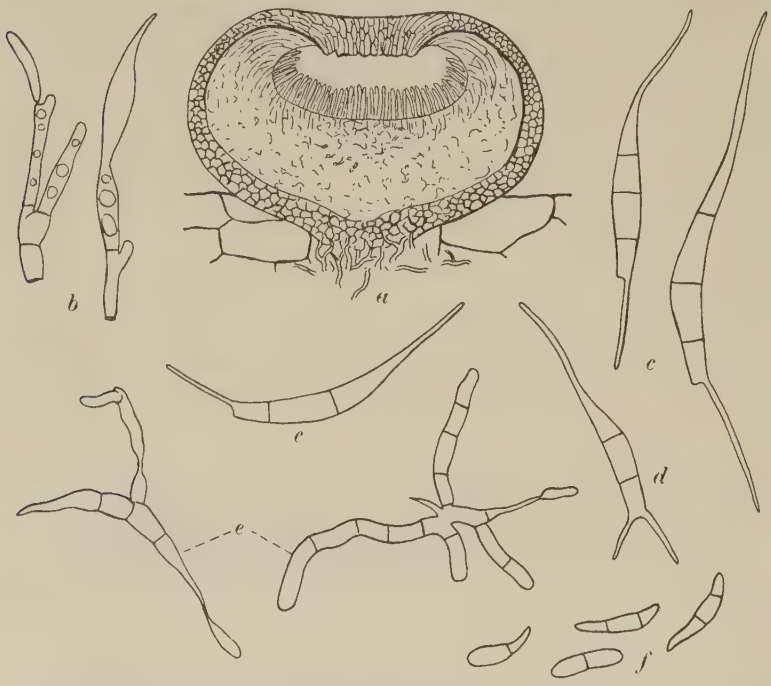

Fig. 3. *Heteropatella Dianthi*. *a*. Vertical section of pycnidium. More or less diagrammatic. *b*. Conidiophores and young conidia. × 850. *c*. Mature spores. × 850. *d*. Abnormal spore with two appendages at base. × 850. *e*. Germination of spores, showing appressoria (?). × 850. *f*. Primary conidia found in cultures on malt agar, etc. × 850.

with appendages usually up to 20 μ long, but occasionally reaching 30 μ. On germination one or both appendages may give rise to terminal swellings suggesting appressoria (Fig. 3, *e*), such as were described by Höstermann and Laubert, and by Salmon and Ware, for the other (*Pseudodiscosia*) stage. The nature of these swellings is not clear; they may be due merely to hyphal growth taking place from the tips of the appendages as well as from the body of the spore. The effect, however, is characteristic for this fungus, and nothing similar was ever observed in *H. Antirrhini*.

Single spore cultures were started both from the *Pseudodiscosia* conidia, and from conidia derived from the *Heteropatella* pycnidia. Repeated platings were made from both forms as material became available, and invariably the cultures thus obtained resembled one another in appearance and behaviour. As in *Heteropatella Antirrhini*, growth is very slow, and freshly isolated cultures tend to produce pinkish, slimy masses of small spores, which are unseptate, or one- to two-septate, and without appendages. In cultures which have been kept for some time the development of conidia ceases. The mycelium within the agar becomes dark brown or blackish, while a mat of whitish aerial mycelium is developed. When any strain has been kept *in vitro* for a considerable period the tendency not to form conidia becomes more pronounced, and the abundant mycelium may be developed at once without the intervention of the slimy, conidia-bearing stage. This was particularly so with a culture of *Pseudodiscosia Dianthi* obtained from the Centraal-bureau at Baarn. Such strains, which do not produce the preliminary slimy layer of conidia, give colonies which become greater in diameter before staling takes place, but the difference in macroscopic appearance of the cultures is not considered to indicate any important systematic difference. The dark colour of the old mycelium is another character in which this species differs from *H. Antirrhini*. A further difference lies in the fact that the extreme tailed conidia are less readily developed both in nature and in cultures. The primary conidia eventually become from one- to three-septate and pointed at each end (Figs. 1, *e*, 3, *f*), but only rarely on the media used by us was there any indication of the development of the characteristic appendages although they were abundant in the Baarn culture on oat agar (Fig. 1, *c*).

In no case has there been any development of pycnidia in artificial cultures of the carnation fungus.

The temperature relations are similar to those of *H. Antirrhini*. On thick malt agar plates growth is best at 19–20° C., but it is almost as good at cool laboratory temperatures of 11–16° C. At 25° C. the growth becomes thick and compact, with very little lateral extension, while at 30° C. there is no visible growth at all. The rate of growth is indicated by the fact that after one month at 19–20° C. vegetations from spores reach a diameter of only 22 mm.

Owing to the absence of pycnidial formation in cultures, it became necessary to rely more on inoculation tests for direct evidence of connection between the *Pseudodiscosia* and *Heteropatella*.

On May 13th, 1927, six varieties of healthy border carnations were sprayed with spores derived from a pure culture of *Pseudo-*

discosia Dianthi. By June 13th there were definite lesions on three of the varieties, and small doubtful spots on a fourth. Eventually, with continued cool and wet weather, most of the plants in the inoculated area became infected, although the same varieties in an uninoculated area separated by a few yards remained healthy. Early in January, 1928, pycnidia of the *Heteropatella* type were found to be present on the old leaves of the affected plants.

On March 1st, 1928, a carnation of the variety "Flesh Pink" was sprayed with a spore suspension derived from a pure culture of the *Heteropatella*. On April 11th this plant showed definite lesions with acervuli of the *Pseudodiscosia* type and the primary form of conidia.

There is therefore no doubt that *Pseudodiscosia Dianthi* is related to a species of *Heteropatella*, just as *Cercosporella Antirrhini* was found to be related to *Heteropatella Antirrhini*. The *Heteropatella* on *Dianthus* appears to be distinct from other species of the genus, not only in its parasitism on *Dianthus*, but also in the small pycnidia, and in the peculiar formation of swollen bodies at the tips of the appendages on spore germination. It may be called *Heteropatella Dianthi* sp. nov.*

The existence of two stages, both belonging to the Fungi Imperfecti, in these two species, *H. Dianthi* and *H. Antirrhini*, raises a point of nomenclature which requires a little consideration. In fungi with a pleomorphic life cycle, the International Rules state that the name to be used is that which was first given to the perfect stage. At present no perfect stage has been found for the fungi in question, and it might be argued that the generic name *Pseudodiscosia* is to be preferred as having been applied to the most conspicuous stage†. In referring to the fungus as a whole, however, it seems to us that it would be preferable to use the generic name *Heteropatella*, on the grounds that the pycnidial stage may be regarded as of more advanced

* *Heteropatella Dianthi* Buddin et Wakef. Pycnidia epiphylla, erumpentia, sparsa, 250–500 μ diametro, globoso-depressa, demum irregulariter dehiscentia, tunica fusca, molle praedita. Substantia interna albida, ex hyphis crasse tunicatis densissimeque intertextis composita. Discus conidiophorus concavus, pallidus. Conidiophora dense verticaliter disposita, filiformes, ramosa, 30–40 μ × 3–5 μ. Conidia falcata, utrinque attenuata, hyalina, plerumque 2–3 septata, 20–25 μ × 4–5 μ, apice appendiculo filiforme 12–20 (–30) μ longo praedita, basi propter appendiculum breviorem quasi pedicellata. Conidia in globulos sordide albidos emergentia.

Hab. In foliis putridis *Dianthi caryophylli*, socie *Pseudodiscosia Dianthi* Hösterm. et Laub.

† As stated in dealing with the *Antirrhinum* parasite, the authors now consider that the parasitic stage should not be referred to the genus *Cercosporella*. If a generic name is required for that stage alone, then certainly *Pseudodiscosia* should be used, and the fungus called *Pseudodiscosia Antirrhini* comb. nov.

development morphologically than the Hyphomycetal stage, and still more because that generic name indicates at once the probable real affinities of the fungus, *Heteropatella* being an old and well-known genus, representing the pycnidial stage of *Heterosphaeria*. Should at any time the ascospore stage of either species be found there would be no difficulty, as the name of that stage would be the valid designation.

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A LEAF-SPOT OF ARCTOSTAPHYLOS MANZANITA.

By A. K. Briant, B.A., and E. B. Martyn, B.A.

(With two Text-figures.)

IN 1927 some diseased shoots of *Arctostaphylos manzanita* were sent for investigation to the Botany School, Cambridge. The plant is a rather uncommon, evergreen shrub, the leaves of which are medium sized, and have a thick cuticle. The bark on the older portions of the stem is shed annually. In the plant in question, the leaves were covered with brown spots, occurring principally on the upper surface, in a degree varying from one or two spots on some leaves, to an almost total discoloration of others (Fig. 1). There was only one plant present in the nursery garden from which the specimens were sent, and it seemed healthy in other respects; but its value as an ornamental shrub was lost owing to the disfiguration of the leaves. The nursery-man stated that the spots, which were also present on the young stems, appeared on the new leaves every year, especially in the summer and early autumn. Moreover, in the few cuttings which had been established (the plant is a difficult one to propagate), although apparently healthy shoots had been used, spots began to appear on the leaves within two or three months.

Upon investigation, it appeared that the brown spots were due to cork formation, associated with the presence of a certain fungus. The leaves, petioles, and stems of young shoots, were found to be covered with a thin surface growth of hyphae, occurring principally on the upper surface of the leaves, but present to a smaller degree on the lower surface also. Many of the stomata were blocked with hyphae, which formed coils in the apertures. Though chiefly present on the surface, the hyphae

also ramified to a certain extent below the cuticle of the leaf, in the outer wall of the epidermis; but they did not penetrate further into the tissues (Fig. 2). Conidiophores arising from the subcuticular hyphae penetrated the cuticle at intervals. Whether they arose from the surface hyphae also was difficult to ascertain, as these were invariably displaced in any attempt to cut sections of the leaf.

Fig. 1. *a*. Shoot of diseased plant showing leaf-spots. Actual size. *b*. Spores of the *Macrosporium* type in culture. × 900.

At certain points on the leaf surface, the hyphae were more closely aggregated, and the fungus fructified, as shown by the presence of conidia of the *Macrosporium* type (Fig. 1, *b*). Immediately below the portions of the leaf surface, where the fungus was most abundant, the host plant was stimulated to form a layer of cork.

Prior to cork formation, generally some of the epidermal and palisade cells became filled with a reddish sap pigment. The upper layer of palisade cells began to divide transversely, the cell contents becoming darker, and the chloroplasts disorganised. Further transverse divisions occurred, accompanied by a suberisation of the cell walls, and finally a fairly definite cork cambium appeared, by means of which a layer of suberised tissue, some four to five cells deep was formed (Fig. 2). The effect of this cork formation was a lifting, and consequent rupture, first of the cuticle, and later of the epidermis, over the spot. This raising of the epidermis soon became evident, even in the smaller spots, and resulted in the breaking away of the cuticle, and subcuticular layer containing the hyphae. In older leaves, most of the upper surface of the leaf was covered by a cork layer.

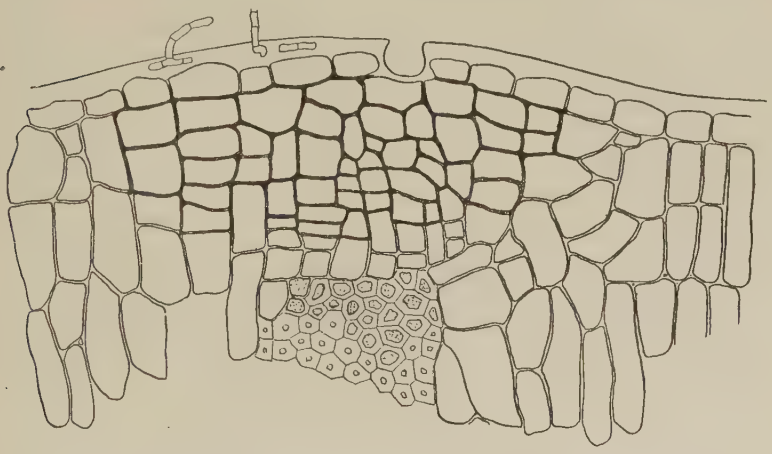

Fig. 2. Transverse section of leaf through a spot, showing the fungus in the cuticle, and suberised cells in the mesophyll. Much magnified.

The phenomenon of suberisation here displayed is of peculiar interest, for, as the fungus does not penetrate the tissues of the host beyond the outer walls of the epidermal cells, the initiation of cork formation must occur in response to a stimulus acting at a distance, and passing at least through the epidermis. Although the presence of a reddish pigment is often to be noticed in the epidermal cells prior to cork formation, the latter process is definitely initiated in the palisade cells. The differentiation of the suberised tissue is shown clearly in sections stained with Schultze's reagent.

Single spores of this fungus of the *Macrosporium* type were isolated, and germinated upon Dox's medium at laboratory

temperature. They gave rise to a mycelium and further formation of conidia, which were three- to five-septate and 23–44 μ × 14–20 μ. In due course perithecia and asci were formed, which were undoubtedly those of *Pleospora herbarum* (Pers.) Rabenh. The seven-septate ascospores measured 30–38 μ × 13–17 μ, and the perithecia were 300–450 μ in diameter, which dimensions agree almost exactly with those given by Lindau (1) and Saccardo (2).

No inoculation experiments could be carried out with the fungus isolated, as healthy shoots of *Arctostaphylos manzanita* could not be obtained.

There has been in the past some confusion with regard to the several species of *Macrosporium*, and their relations to a perithecial form. Miyabe (3) described *M. parasiticum* Thuem. as identical with *M. sarcinula* Berk., and as giving rise to perithecia of *Pleospora herbarum*, whereas Saccardo (2) stated that this latter fungus produced *M. commune* Rabenh. as its conidial form. Brefeld (4) held *M. sarcinula* and *M. commune* to be identical, and Stevens (5) added *M. parasiticum*, considering all three to belong to one species which he called *M. commune*.

Further work on these relations has been carried out by Bolle (6). According to her, *P. herbarum* shows several different "morphological-biological" races, two of which give rise respectively to *M. parasiticum* Thuem. and *M. sarciniforme* Cav. (hitherto looked upon as separate species). These are to be regarded as different races of one species, morphologically indistinguishable in culture, but differing very slightly when on their respective hosts. She considers that "Der Name *Macrosporium sarcinula* kann für die allgemeine Konidienform von *Pleospora herbarum* beibehalten werden, von der die Konidienformen der verschiedenen Rassen morphologisch nicht zu unterscheiden sind" (p. 68). She also indicates that *M. commune* Rabenh. is identical with *M. sarcinula* Berk.

On this interpretation, the fungus under discussion in this paper would be classed as *M. sarcinula* Berk., the conidia of which, according to Bolle, measure 20–49 μ × 12–29 μ.

In conclusion, our thanks are due to Mr F. T. Brooks, under whose advice this investigation was carried out, and to whose assistance and criticism we are indebted.

Summary.

1. The brown spots on the leaves of a plant of *Arctostaphylos manzanita* were found to be due to cork formation associated with the presence of a fungus of the genus *Macrosporium*. The fungal hyphae occurred on the surface of the leaves and in the

outer epidermal walls, but did not penetrate the epidermal cells. The palisade cells below were, however, stimulated to form a layer of suberised tissue.

2. The fungus in culture gave rise to perithecia of *Pleospora herbarum*, and the conidia were classed, in the light of recent work, as *Macrosporium sarcinula* Berk.

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A NEW SPECIES OF HEMITRICHIA FROM JAPAN.

By G. Lister, F.L.S.

(With Plate IV.)

In April, 1928, I received from Dr Hattori, of the Biological Laboratory, Imperial Palace, Tokyo, Japan, two specimens of Mycetozoa. They are mounted in glass-topped boxes and are accompanied by photomicrographs illustrating their structure.

Both of the specimens had been collected in the palace grounds by the Emperor of Japan himself. They were no chance gatherings, for the Emperor has made a special study of Mycetozoa and has observed them extensively in the field. Students of Mycetozoa in all lands will learn with deep interest that they have so distinguished a colleague.

One of the specimens is a fine growth of *Physarella oblonga* (Berk. and Curtis) Morgan, a species not previously recorded from Japan.

The other is a *Hemitrichia*, the determination of which, as Dr Hattori wrote, presents some difficulty. The tawny-yellow sporangia are clustered and shortly stalked; the walls are broken away above, and the emerging masses of capillitium consist of sparingly-branched flexuose threads marked with three or four smooth or spinulose spiral bands.

In August, 1928, I received from Dr Hattori a further specimen of the *Hemitrichia*, which had developed in his laboratory from a culture of spores taken from the former gathering. He

records that the spores were sown on February 1st, 1928, on carefully sterilised rotten wood, and were kept at a temperature of 21° C.; from April 19th onwards the culture was exposed to the temperature of the laboratory; on April 30th sporangia had formed. This fresh development is perfectly matured and resembles the parent growth in all essentials. The glossy sporangia are pale copper-coloured, curved and somewhat contorted; they are mostly sessile and form a compact cluster about 8 mm. across; the capillitium threads are so little branched as to constitute a twisted skein rather than a network, and are marked throughout with three or four sharply-defined smooth spiral bands, the spirals having a sinistral arrangement.

In some respects this form shows affinities with *Hemitrichia leiocarpa* (Cooke) Lister, a rare species which differs in the sporangia being yellowish-grey and more scattered, and in the spiral markings of the capillitium having a dextral arrangement. In all other species of *Hemitrichia*, as well as in the allied genus *Trichia*, the direction of these spirals is sinistral.

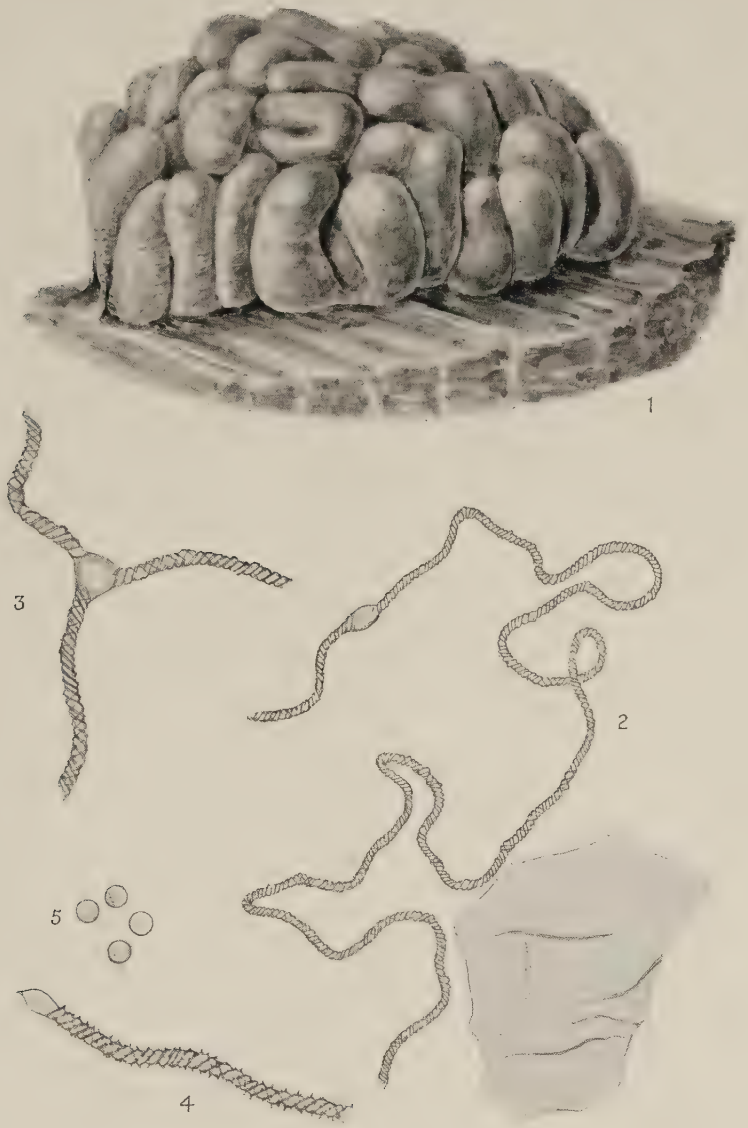
Externally the present specimen closely resembles some developments of *Arcyria stipata* (Schwein.) Lister, a widely-distributed and variable species, recorded from Japan by Mr Kumagusu Minakata, in which the network of capillitium is marked with cog-like or half-ring-shaped thickenings, and also with three or four delicate spiral bands; the latter are often apparent only on the basal threads. The cog-like markings are characteristic of the genus *Arcyria*, and the spiral bands of *Hemitrichia*. Prof. T. H. Macbride therefore in *North American Slime-Moulds* places *A. stipata* in the genus *Hemitrichia* and regards it as "a boundary species."

The specimen we are now considering is, however, from the markings of the capillitium completely a *Hemitrichia*, and one which corresponds with no published description.

Having received Dr Hattori's permission to describe the new species, I have the honour to propose for it the name *Hemitrichia imperialis* to commemorate the fact that it was first gathered by the Emperor of Japan. I may add that the Emperor has graciously presented his gathering to the British Museum.

Hemitrichia imperialis n. sp.

Colour of plasmodium not observed. Sporangia clustered, shortly stalked or sessile, cylindrical, curved, 0·8 to 1·5 mm. high, pale copper-coloured, fading to dull tawny-yellow; sporangium-walls more or less persistent, nearly smooth or marked with transverse wrinkles below, smooth above. Stalk nearly black, attaining 0·3 mm. in height, filled with spore-like cells. Capillitium consisting of sparingly-branched flexuose threads,



HEMITRICHIA IMPERIALIS N. SP.

4 to 4·5 μ diam., unattached to the sporangium-walls and with few or no free ends, marked with three or four prominent spiral bands; the latter are either smooth or spinulose and have a sinistral arrangement. Spores in mass pale copper-coloured or dull yellow, smooth or marked with a few faint scattered warts, 6·5 to 7 μ diam.

Habitat. On decayed wood in the grounds of the Imperial Palace, Tokyo, Japan.

Latin diagnosis. Peridiis congestis, curvatis, stipitatibus vel sessilibus, dilute cupreo-coloratis, membrana subpersistente; stipite breve, fusco; tubulis capillitii flexuosis, raro ramosis, 4–4·5 μ diam., taeniolis spiralibus, sinistrorsis, 3–4, laevibus vel spinulis minutis armatis; sporis fere laevibus, dilute cupreo-coloratis, 6·5–7 μ diam.

Dr Hattori is much to be congratulated on his success in obtaining sporangia from a spore culture, a success rarely obtained in the laboratory with one of the Mycetozoa inhabiting wood.

EXPLANATION OF PLATE IV.

Fig. 1. Group of sporangia from Dr Hattori's spore culture; two stalked sporangia are seen to the left, the rest are sessile. × 20.

Fig. 2. Capillitium with fragment of wrinkled sporangium-wall. × 280.

Fig. 3. Branching capillitium with smooth spiral bands. × 460.

Fig. 4. Capillitium showing a free end, and with spinulose spiral bands. × 460.

Fig. 5. Spores. × 460.

SOME OBSERVATIONS ON MYCETOZOA OF THE GENUS DIDYMIUM.

By Dorothy M. Cayley, John Innes Horticultural Institution.

(With Plates V and VI and three Text-figures.)

Several species of *Didymium* lend themselves to experimental investigation. The spores germinate easily and well, and though the different species discussed in this paper vary somewhat, germination does not depend, as in many Mycetozoa, on a very delicate osmotic balance between spore content and the surrounding medium or solution.

Within recent years a considerable amount of work has been done by various investigators on the conditions necessary for the germination of spores of different species of Mycetozoa, but very little is known as to the conditions which bring about sporulation. The solution of this problem is very difficult, as normal development must depend upon the complex interaction

of so many factors such as moisture, light, temperature, consistency and composition of substratum, the type of organism carried on the spore coat, which may or may not influence the early stages of growth and serve as food during development, and so on.

By a fortunate accident, a suitable medium for the growth of *Didymium* was hit upon in 1924. A profuse crop of sporangia of *D. nigripes* var. *xanthopus* appeared as a contamination in one of Miss I. Andersson's fern cultures among fern prothallia growing in Knop agar in a Petri dish in one of the experimental greenhouses at this Institution. The method of growing ferns on Knop agar had been devised some years earlier by Miss Andersson. Being colourless and more or less transparent, it proved most satisfactory both for the growth of ferns under strict control and for the purpose of watching the germination of spores, the development of the prothallia and early sporophyte stages *in vivo* under the microscope.

The appearance of sporangia of *Didymium* on this medium suggested that it might also be suitable for the culture of Mycetozoa with or without the presence of a green plant.

Preliminary tests with *D. nigripes* var. *xanthopus* and, later, attempts to grow other species of this genus on Knop agar, proved that the presence of a green plant is not necessary for normal development and the production of sporangia with viable spores.

Contamination of the fern cultures with *Didymium* occurred on two separate occasions, the first time the contaminating organism was *D. nigripes* var. *xanthopus*, the second time the type form *D. nigripes*.

The present author lays no claim to be the first to grow Mycetozoa on a solid synthetic medium. As early as 1900 Klebs (16) grew *D. difforme* and *D. effusum* (syn. *D. squamulosum*) on agar. Pinoy (21) and Skupienski (22, 23, 27) have grown various species on a gelatine medium, Bělař on Knop agar and so on. Knop agar is a medium used by protozoologists, and being slightly acid has the advantage of keeping down excessive bacterial growth, and does not liquefy.

No serious attempts have been made to eliminate bacteria from the cultures; in fact it is almost impossible. The spores in some cases were treated with a solution of 2 grm. mercuric chloride dissolved in 1000 c.c. of equal parts of distilled water and absolute alcohol for five minutes. The spores were then washed rapidly in several changes of sterile distilled water, the suspension being centrifuged between each change. This treatment reduced the percentage of germination, and after germination, although not absolutely free from bacteria, the cultures

did not do so well as those from spores less drastically treated with 20 per cent. alcohol for times varying from a few minutes to one hour.

In a recent paper Skupienski(27) describes how he was able to obtain cultures free from bacteria by using spores from a four-year old culture, in which the bacteria had died out. The spores germinated quite well, the gelatine medium was not liquefied and plasmodia developed. But the growth of the plasmodia was feeble and they never sporulated.

On the other hand, heavy bacterial contamination is detrimental, more especially during the early stages of growth; but once a culture is established and growing well, the dishes may be opened for observation purposes under the microscope without any very serious risk of undue contamination from the air. For the most part, if the cultures are growing freely, fungus colonies are kept down by the myxomycete; but once contaminated with species of *Penicillium* it is almost impossible to purify the culture. *Penicillium* not only grows and sporulates rapidly, but also, as Gilbert(7) has been able to show, many Mycetozoa will not ingest spores of *Penicillium* at all, and if by chance the spores are ingested, the amoebae do not appear to be able to digest them, unless the spores have been previously treated with alcohol.

Yeasts are detrimental at any stage, chiefly on account of their rapid growth, but also because they probably produce chemical changes which are deleterious. Cultures containing sugars are especially liable to yeast contamination. The sugars encourage excessive growth of the yeast at the expense of the myxomycete. When cultures are free from yeast the sugar in the medium stimulates the growth of the myxomycete also; the development is more rapid but somewhat coarse and abnormal. Recently another medium has been tried, namely butter bean agar. Various species of mycetozoa grow well on this medium, and, as far as growth is concerned, this medium is an improvement on Knop agar, but has the disadvantage of encouraging excessive bacterial development, more especially when freshly poured. If the plates are poured and allowed to stand for about a fortnight, the medium is drier and useful for sub-culturing well-established clean cultures, but not for sowing fresh spores.

Differences in the constitution of the medium and the amount of moisture present can give rise to more or less marked morphological changes. Skupienski(27) found that the fructifications of *Didymium difforme* differed from the normal both in external appearance and internal structure according to the different species of fungi or bacteria present in the culture. The effect of

different organisms on the fructifications of the several different species of *Didymium* touched upon in this paper has not been investigated, but some of the effects produced by the chemical constitution of the medium and the moisture conditions have been noted.

For instance, *Didymium nigripes* var. *xanthopus*, when grown on Knop agar containing 2–5 per cent. cane sugar, produces coarse sporangia, somewhat larger than the normal, lobed rather than sub-globose, and either stalked or sessile. When stalked, the stalks are shorter and much thickened at the base (Pl. V, figs. 5, 6), when sessile, compound sporangia are often found very irregular in shape, somewhat resembling the plasmodiocarps of *Didymium difforme*.

Again, the difference between the sessile and stalked forms of *Didymium squamulosum* appears to be mainly due to external conditions. A sowing of spores from the sessile form gathered on dead leaves in the open, developed the stalked form under moister conditions on a plate of Knop agar in a Petri dish (Pl. V, figs. 8, 9).

Attempts were made to grow single spore cultures of *D. nigripes* and its yellow stalked variety *D. nigripes* var. *xanthopus* with the object of trying hybridization experiments between the two forms. The single spore cultures grew well and fructified, but the colour of the stalks was so variable in both forms, more especially when grown on a colourless medium such as Knop agar, that they could not be distinguished from one another with any degree of certainty, and the experiment had to be abandoned.

As a general rule, but not invariably, the degree of colour in the stalk is more or less correlated with the depth of colour in the medium. In *D. nigripes* var. *xanthopus*, when grown on colourless Knop agar, the stalks are pale and sometimes almost devoid of colour: on Knop agar containing 5 per cent. cane sugar they show more yellow: on Knop agar and infusion of holly leaves, a pale brown medium, the stalks are darker: and on sterilised holly leaves they can be dark brown to black, and might be mistaken for the type *D. nigripes*. All the columellae examined, however, were white. Dry conditions also tend to deepen the colour of the stalks. Several sporangia on various media are figured in Pl. V, figs. 1–6. The morphological differences can be seen, but the colour of the stalks does not show up well in the photographs.

In multispore cultures from a single wild sporangium with a dark columella from a specimen identified by Miss Lister as typical *D. nigripes*, occasional sporangia appeared with brown columellae, much the same colour as the stalk, but the majority

showed white columellae, and both forms of sporangia occurred in the same sub-culture derived from a piece of plasmodium taken from the above mentioned monosporangial culture.

This agrees with the variability observed in nature described by Lister, and it appears hardly possible to draw a hard and fast line between the several different forms or varieties of *D. nigripes*. However, a pure breeding strain of *D. nigripes* may yet be found, and this variability may perhaps be due to the occurrence of hybrid forms between *D. nigripes* and *D. nigripes* var. *xanthopus* or possibly *D. eximium*.

It has been noticed that sowings of typical *D. nigripes* with dark columella are more difficult to germinate than the variety *xanthopus*, and the failure to obtain the type from the culture, except occasionally, may mean that some sporangia contain mixed spores, and that owing to the delay in the germination of the type spores, the sub-cultures contained only the variety *xanthopus*. Further work is required on this point, and the suggestion is only put forward tentatively.

Conditions influencing growth.

The conditions influencing growth and the details of the early stages of development described below apply more especially to *D. difforme*. The other three species touched upon in this paper were not studied in such detail.

It is impossible to generalise as to conditions for growth for the Mycetozoa as a whole, but there can be no doubt, however, that the amount of moisture present plays a very important part in the environmental conditions conducive to growth and development of all Mycetozoa, more especially in the early stages and during the initial stages of sporangial and spore formation.

The spores of *D. difforme*, if previously thoroughly wetted, germinate as well on a solid medium, such as freshly poured agar, as in water, but they germinate much more rapidly on plain agar than on Knop agar.

As pointed out by Dickinson (6), there is always a thin film of water on the surface of freshly poured agar. This film is quite sufficient to allow the emerging swarm spore to creep freely over the surface in search of food; but as soon as this film begins to dry out, the swarm spore rounds itself off and becomes quiescent, and, if it is kept in this condition, encysts. More water than is contained in this thin film is necessary for the swarm spores of *D. difforme* to pass from the amoeboid to the ciliate motile condition. The undivided swarm spore, if given sufficient water, can become motile before any division has taken place; or, as is more usual, the amoebae, after creeping about for some time, round themselves off and undergo several

divisions before the motile stage begins. After a period of motility of variable duration, the swarm spores will settle down again and round themselves off temporarily without encysting, in spite of the presence of sufficient moisture. Divisions take place during this temporary condition of quiescence. The swarm spore becomes ovoid, a transverse constriction occurs, and division is complete in a few minutes after the constriction has appeared. Division in the amoeboid or motile condition has not been seen.

This alternation from motility to quiescence, accompanied by division, can occur several times if water is added at intervals.

After a number of divisions continuing for two or more days after germination, the cultures reach a stage at which the swarm spores are ready to fuse. Previous to this stage the motile swarm spores, although present in large numbers, often come in contact with one another but make no attempt to fuse. In *D. difforme* water is of extreme importance at the fusion stage, as fusion takes place only between motile gametes, and there must be enough moisture present to enable them to swim about freely and remain motile for some hours. The actual process of fusion will be described in detail later.

Once the fusion has taken place, the zygotes may either round themselves off, when dry conditions prevail, or pass direct into the amoeboid condition, push out pseudopodia and creep over the surface of the medium. Zygote and haploid amoebae may be seen lying singly or in groups of two, three or many, but retain their individuality for a time, continue to feed, and change in shape and position although more or less in contact with others. The complete coalescence of amoebae to form plasmodia has not been seen. It is doubtful if this process takes place at all at this stage in *D. difforme*, and if it does, the process is very slow. Under conditions which allow of free movement and spread of amoebae, both haploid and diploid, they appear to coalesce, but if a drop of fresh water is added, the amoebae contract again for a few minutes, and separate, showing that they have not lost their individuality. Groups of amoebae of different sizes have been watched for upwards of eight hours without showing complete coalescence, although numerous small plasmodia developed in the same culture during that period.

After the fusion of gametes, the protoplasm of the zygote remains clear for a time, so that in the amoeboid condition it cannot be distinguished from a haploid amoeba, but when rounded off or encysted there is a marked difference in volume between the two. The transition from the clear to the granulate condition of the young plasmodium has not been seen. The zygote is usually regarded as a young plasmodium, but the

fact that the zygote at first looks and behaves like an amoeba, has led to this distinction being drawn between the two conditions. Different degrees of vacuolation of the zygote amoeba have been seen in cultures, and this vacuolate condition appears to be a transition stage between the zygote amoeba and the typical plasmodium with granular contents.

The presence of numerous minute plasmodia in young cultures suggests that plasmodia can arise from a single zygote, and certainly under artificial conditions mostly do so. A young plasmodium does not coalesce immediately with amoebae with which it comes in contact, but has been seen to remain in a quiescent condition in close contact with several amoebae for hours without ingestion or coalescence. The same has been recorded by Jahn (14) in *Physarum didermoides*; in this species plasmodia do not coalesce with amoebae but only with other plasmodia. Both Cienkowski (3) and Jahn (14) saw coalescence of young plasmodia in *Didymium effusum*. Wilson and Cadman (29) found that in *Reticularia Lycoperdon* groups of haploid swarm spores coalesce with a pair of fusing gametes, and came to the conclusion that the nuclei of unfused swarm spores eventually serve as food for the developing zygote. Plasmodia of varying sizes can be seen in young cultures of *D. difforme*, some so small that they cannot possibly have arisen from more than one or two zygotes, and others considerably larger, but the actual coalescence of plasmodia was not seen. The size of the plasmodia in older cultures must depend considerably on whether external conditions are conducive to free spread both for feeding purposes and coalescence sooner or later with other plasmodia, or possibly other zygotes.

The plasmodia in these three species of *Didymium* are not light shy; given adequate moisture they creep about in all directions in daylight and also under strong artificial illumination under the microscope.

It is common knowledge that plasmodia are sensitive to varying conditions of moisture, but can survive in the dry state for a considerable period, sometimes years. In culture, if kept too dry, the plasmodium contracts, the streaming of the protoplasm becomes sluggish and eventually ceases entirely. On re-moistening the plasmodium will spread again, or if left in the contracted condition will produce one or more plasmodiocarps according to the size of the plasmodium. Sclerotia, as described by Brandza (1) in *D. difforme*, have not been seen by the present author in cultures of this species on a synthetic medium. Although young plasmodia will develop in a hanging drop, increase in size of the older plasmodia is not so marked when they are kept too wet as when the surface of the medium

is just sufficiently moist to enable the plasmodium to spread freely, exposed to moist air, without undue friction with too dry a medium.

The duration of the plasmodial stage varies with different species and with external conditions. Given adequate growing conditions, this period is short in *D. difforme* and longer in *D. nigripes* and *D. squamulosum*. But what it is that incites the plasmodium of any given species, which, in its natural habitat, passes the plasmodial stage inside the substratum, to creep to the surface, or in those forms with superficial plasmodia, to seek out drier conditions to fructify, is still a complete mystery.

Klebs (16) in 1900 held that depletion of food substances was the deciding factor in the initiation of spore formation, as he was able to stave off sporangial development in plasmodia of *D. difforme* and *D. effusum* for a whole year, by repeated and frequent sub-culturing on to fresh medium. Jahn also found that plasmodia of *Badhamia utricularis* would produce sporangia when starved and kept under cool conditions, sclerotia when exposed to the dry atmosphere of a room, and yet would remain in the plasmodial condition for prolonged periods if sub-cultured at short intervals. He makes no reference however to the moisture conditions pertaining in his starved cultures, neither does he consider the possible influence of accumulations of waste products.

D. nigripes, *D. nigripes* var. *xanthopus* and *D. squamulosum* when grown on a synthetic medium fructify more profusely on the sides of the Petri dish, where the agar has contracted leaving a thin dry film on the glass, than in the centre, where the agar is thicker, more moist, and where there is an abundant food supply. The plasmodia themselves seek out these drier conditions, although they are free to spread in all directions over the surface of the agar. The necessity for drier conditions for sporulation does not hold good for *D. difforme*. In this species plasmodiocarps can be seen scattered all over the surface of the agar, when conditions are still moist, Pl. V, fig. 10, and moreover submerged sporangia appear sooner or later in most of the older cultures between the base of the Petri dish and the superimposed layer of agar. The amoebae and plasmodia cannot actually penetrate the agar; but when the agar layer is thick, after a time it contracts and splits open, thus enabling the plasmodia to creep down and spread between the agar and the base of the Petri dish (Pl. V, fig. 12).

Aquatic conditions do not appear to be necessarily adverse to sporangial development in *D. difforme*. Marshall Ward (28) describes a completely submerged healthy growth

of this species on the roots of hyacinths growing in a nutrient solution.

The size and age of the plasmodium does not appear to be correlated with the development of plasmodiocarps in this species. Very small plasmodia, which cannot have undergone many nuclear divisions, will form minute more or less spherical sessile sporangia containing very few spores, whereas the older larger plasmodia give rise to one or more typical plasmodiocarps containing innumerable spores (Pl. V, figs. 10, 11).

On the other hand, in the two species *D. nigripes* and *D. squamulosum*, with sporangia more uniform in size and shape, the plasmodia have to grow to a certain size before sporulation begins, and then a number of sporangia are produced more or less simultaneously on one and the same plasmodium. In a culture of *D. squamulosum* on Knop agar, a large plasmodium crept up on to the lid of the Petri dish, and formed over a hundred sporangia on the lid only. No sporangia developed on the surface of the agar on which the culture had been grown (Pl. V, figs. 8, 9).

Exhaustion or depletion of food substances does not appear to play an important part in the initiation of sporulation, as far as these three species of *Didymium* are concerned. They were grown on Knop agar, were watered alternately with Knop solution and sterile rain or distilled water, and bacteria were always present in large numbers to serve as food. No work has been done, so far, on the effect of the accumulation of waste products of growth on the production of fruiting bodies.

Loss of water during the early stages of sporangial development.

In the early stages of sporangial development Harper and Dodge (11) maintain that evaporation accounts for the greater condensation of the protoplasm in the process of passing from the "extended vegetative condition to that of the dust-like spores." Harper observed the extrusion of sap during the protoplasm cleavages in the sporangium previous to spore delimitation in *D. melanospermum* and later in *Fuligo varians*. At first the condensation of the protoplasm is greater at the periphery and in the region round the columella, than in the interior of the sporangium: he states "there seems to be an obvious parallel between facility of water loss and rate of cleavage, but this in no wise excludes the possibility that chemical changes in the plasma membrane also favour the active extrusion of moisture through all the cleavage stages." Harper (9) also points out that the coincidence of nuclear divisions and cell divisions varies according to the species. In *Fuligo* the two processes are

simultaneous, in *Trichia* nuclear division is complete before cell division begins. The aethalia of *Fuligo* develop more rapidly than the sporangia of *Trichia*. During the later stages of sporangial formation therefore drier conditions are necessary and loss of water is an essential, but not the only factor concerned.

The extreme variability in size and shape of the plasmodiocarps of *D. difforme* in culture and probably in the open, depends to a certain extent on external conditions. Every size and shape, from minute spherical sporangia containing four spores (Pl. VI, fig. 5) to the typical irregular shaped plasmodiocarps containing innumerable spores, have been seen both in the mono- and multispore cultures.

On deep plates of Knop agar, kept sufficiently moist to enable the plasmodia to spread freely and coalesce with others, normal plasmodiocarps are generally found; but if a young culture containing numerous small isolated plasmodia is kept rather on the dry side, the plasmodia contract and form small, more or less spherical, sporangia. At times the process of spore formation appears to be arrested in the smaller plasmodia, giving rise to peculiar structures. These consist of an aggregate of chambers formed by the slight contraction of the granular contents of the plasmodium into masses of different sizes, leaving radiating lines of clear protoplasm. These lines gradually become tinged with brown, and eventually are of the same dark brown as the walls of the normal spores. These bodies develop very slowly, and may form a few apparently normal spores in one or other of the chambers, or may be completely abortive (Pl. VI, figs. 1, 2, 3, 4, 7).

Sex in *D. difforme*.

In his paper of 1928 Skupienski has stated that the spores of *Didymium difforme* are not only haploid but unisexual. He was unable to obtain plasmodia in monospore cultures, but only when he combined two such cultures. This point was of such interest and importance that a series of monospore cultures of *D. difforme* were started on Knop agar in order to confirm, or disprove this statement.

The material used was obtained from plasmodiocarps on bracken gathered in 1926.

The spores of *D. difforme* are variable in size, but only those of normal size were isolated for these tests. Giant spores, probably due to the failure of the nucleus to undergo the final division before spore formation, are frequent both in cultures and in nature, but they have never been seen to germinate.

The technique employed for the isolation of single spores was a modification of the De la Rue (5) method. The De la Rue objective was used, fitted with a cutting cylinder having the

aperture of a 1/6 objective, but 2 per cent. agar substituted for gelatine as a medium on which to spread the spores. Agar was found to be much more convenient than gelatine, more especially in hot weather, and does not foul the cutter when heated between each isolation.

The method is as follows: a thin suspension of spores is made in sterile distilled water or tap water on a hollow ground slide (if the spores burst in distilled water, tap or rain water should be used), and the spores, if difficult to wet, should be previously treated with 20 per cent. alcohol for a few minutes. Five or six drops of sterile water are then spaced on the surface of a thin plate of cold agar in a Petri dish, a platinum loopful of the suspension is added to each drop, and the drops gently and thoroughly spread over the surface of the agar with a sterile glass spreader, and the dishes placed in a cool incubator (25–27° C.) for 12–24 hours in order to dry the surface of the agar.

The plate is then examined with a 2/3 objective and high eyepiece, until a single isolated spore is found, and by moving the dish brought into the centre of the field. Care must be taken to examine the agar all round the actual field to make certain that no neighbouring spore is sufficiently close to get caught up on the edge of the cutter. The cutter is then swung round and gently lowered into the agar with the coarse adjustment of the microscope. A circle is thus cut round the spore and the plug of agar can be removed, under a dissecting microscope or watchmaker's lens, with a fine platinum needle, without touching the surrounding agar, and then transferred to another Petri dish or a tube of culture medium. The cutter is sterilised in a Bunsen flame between each isolation. For watching germination, the plug of agar with the spore can be lowered carefully into a hole made by the same cutter in a fresh Petri dish of agar, from which an equal-sized plug has been removed as described.

Three series of isolations were made at different times from the same material. The spores in Series I were treated with 20 per cent. alcohol for a few minutes, to ensure their thorough wetting; those in Series II and III with 20 per cent. alcohol for one hour. The percentage of germination was roughly 50 per cent. in all three series, showing that the extra time of treatment had no effect on germination (see Table, p. 238).

Out of a total of twenty monospore cultures which grew well, sixteen produced plasmodiocarps.

A second generation of monospore cultures was raised from a monospore culture in Series I, comprising two sets of isolations (Series IV). Of seven cultures which grew well, six produced plasmodiocarps.

Again, a third generation was raised. Ten spores were sown, only three germinated, two grew well and one fructified. The results are tabulated below.

Didymium difforme (monospore cultures).

		No. of spores sown	No. germinated	Good growth	No. of cultures which developed sporangia	Treatment of spores
Series I, 17 XI. 27		20	11	10	7	20 % alcohol a few minutes to wet spores
Series II, 1 XII. 27 (4 discarded because contaminated)		16	8	5	4	20 % alcohol 1 hr
Series III, 13 XII. 27		13	8	2	2	,, ,,
		10	6	3	3	,, ,,
	Total	59	33	20	16	
				F_1		
Series IV		8	6	4	3	No treatment
		5	3	3	3	
	Total	13	9	7	6	
				F_2		
Series V		10	3	2	1	No treatment

The results of these tests, although suggestive, did not constitute definite proof of the bisexuality of the spores, as there was always the possibility that *D. difforme* might be capable of producing haploid fruiting bodies for successive generations, as is known to occur in the Hymenomycetes (8). If so, the plasmodiocarps would contain spores of one sex only, and of the same sex as the parent spore. If the spores are bisexual, then fusion of swarm-spores must occur in monospore cultures; if unisexual, no such fusion would take place.

After several unsuccessful attempts the fusion of three pairs of motile swarm spores in a multispore culture was watched in a drop of water under the microscope between the hours of 12 midnight and 2 a.m., and ten fusions of motile swarm spores in a monospore culture by Miss G. Waterhouse and myself between the hours of 4 p.m. and 1 a.m. Both these cultures were obtained from the same original specimen on bracken. Miss G. Waterhouse has gained the distinction of being the first observer to see the fusion of motile gametes in a monospore culture. In every case, the development of the monospore culture was quite normal and differed in no respect from that of the control multispore cultures.

For watching the fusion of motile gametes in a multispore culture, the following method was adopted.

A drop of sterile distilled water was placed on a slide previously smeared with a thin film of agar, and a large platinum loopful of motile swarm spores transferred from a culture on Knop agar. The slide was then placed in a Petri dish, and the lid replaced for a time to allow the swarm spores to recover from the shock of being transferred to fresh water. Just immediately after transference the swarm spores are apt to round themselves off, or become sluggish in their movements. By this method, the drop spreads on the agar and is liable to dry out after a time, and the process of fusion varies somewhat according to the moisture conditions prevailing on the slide.

For the monospore fusions the above method was modified. A hanging drop preparation was made on a coverslip previously smeared with agar, and supported on sterile pieces of glass over a slide in a Petri dish. Spores from a monospore culture previously treated with 20 per cent. alcohol were sown in the drop, and the culture grew at laboratory temperature for some days, allowing the drop to dry out partially from time to time. After a considerable number of divisions it was seen that, in spite of sufficient moisture, the swarm spores remained quiescent. Fresh water was added, and after about a couple of hours numerous fusions took place.

Fusion of motile gametes.

The motile gametes become attached by their posterior ends. Only those which were already attached were watched; the actual meeting of any two gametes was not seen, and it is not known how long they are thus attached before coalescence and fusion is completed.

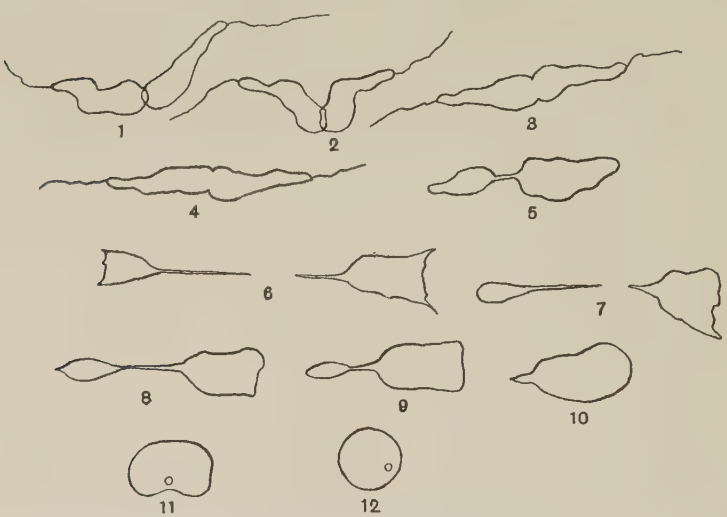
One pair, already attached, was watched for at least half an hour before complete fusion took place.

In a spreading drop, as soon as the water begins to dry out the final stages of fusion are very rapid, lasting only a few seconds. The two text-figures below are semi-diagrammatic and drawn from memory immediately afterwards.

Part of the protoplasm of one of the swarm spores becomes merged in the other (Text-fig. 1 (3), Text-fig. 2 (5)) increasing the volume of the latter, and both become amoeboid. Then the two unequal masses are drawn apart, and a portion of the smaller is drawn out into a long fine connecting strand. When this strand of protoplasm is much elongated, as in Text-fig. 2 (6, 7), the middle portion is so fine as to be invisible under the low power of the microscope, but nevertheless it must be continuous, as the smaller mass is drawn rapidly towards the larger, and fuses with it. A vacuole then appears and the zygote may either contract, round itself off and remain quiescent for a time,

or, if conditions are sufficiently moist, may become amoeboid, push out pseudopodia and creep over the surface of the agar.

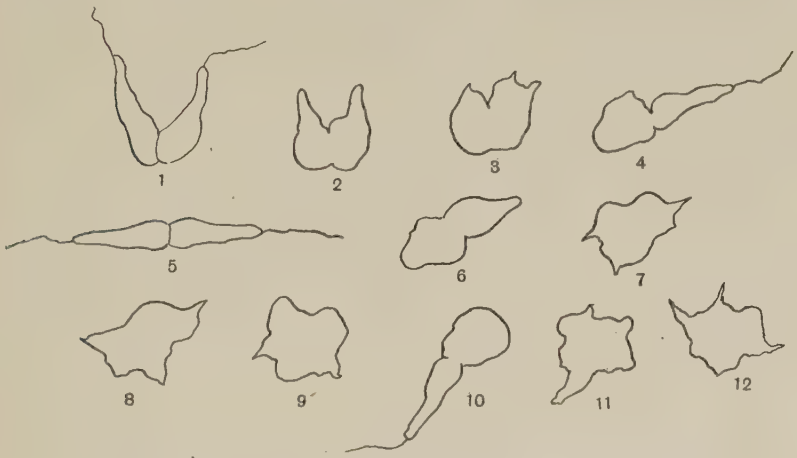
Text-fig. 1. Fusion of motile gametes in a multispore culture of *D. difforme* in a spreading drop. Conditions fairly moist.



Text-fig. 2. Fusion of motile gametes in a multispore culture of *D. difforme* in a spreading drop. Conditions rather dry.

In one of the three fusions seen, the drop dried out so rapidly that both the unequal parts had rounded themselves off before they finally drew up together, but nevertheless the two masses fused.

In a hanging drop, which does not dry out so rapidly, the process is much prolonged (Text-fig. 3). After the two gametes have to all appearances completely fused, and look like a zygote amoeba, one or other or both individuals may elongate again and show motility, although they both remain attached (Text-fig. 3 (4, 5, 10)). They then close up again, and this contraction and elongation may be repeated several times until the zygote eventally becomes a true amoeba, and creeps about without further change.



Text-fig. 3. Fusion of motile gametes in a monospore culture of *D. difforme* in a hanging drop. Conditions wet.

It must not necessarily be inferred that fusion of gametes only takes place after dark or during the night. One fusion in a monospore culture was seen in daylight at 4.15 p.m. It is more probable that the cultures happened to have reached the fusion stage, and that moisture conditions were suitable. In one of the unsuccessful efforts to see fusions the culture was too young, there being no attempt at fusion in spite of the large number of swarm spores seen; in another the culture was evidently too old, as plasmodia and a number of zygotes had already formed.

Many years ago Lister* observed the same kind of process in *Trichia varia*, but the individuals separated again after having been attached by a long slender thread. He never saw the final drawing together and fusion, and, being unable to interpret his observations, they were unfortunately never published.

* My thanks are due to Miss G. Lister for her kindness in giving me this information, for showing me her father's figures, and for allowing me to publish these observations.

The results of the above tests and observations on living material show quite definitely that the spores of *D. difforme* are bisexual, and not unisexual as held by Skupienski.

This is the second example on record of fusion taking place between motile gametes in the Mycetozoa, the first being in the species *Reticularia Lycoperdon* observed by Wilson and Cadman (29). Lister's observations indicate that the same process takes place in *Trichia* also. This type of fusion may prove to be of fairly general occurrence in species with motile swarm spores, and may account for the failure of other workers to see the actual process, as they mostly looked for fusions in the amoeboid condition.

Discussion on sex segregation and nuclear divisions in the Mycetozoa.

Little is known, as yet, about the segregation or differentiation of sex in the Mycetozoa, but it is generally accepted that plasmodia do not develop until fusion or, at any rate, coalescence of gametes has taken place, and that plasmodia may arise from a single zygote, or possibly from the coalescence of a variable number of these. Haploid amoebae, motile or encysted swarm spores may get caught up during the process of plasmodium formation, or during the creeping feeding stage, but as yet there is insufficient proof that these bodies serve any other purpose than that of nutrition.

Skupienski (27) states that the plasmodium of *D. difforme* is made up, not only by the coalescence of two myxamoebae of different sexes, but also by a number of myxamoebae, and he calls this new element collectively a zygote. He maintains that the nuclei do not fuse at this stage, but remain distinct and haploid, dividing caryokinetically during the growth of the plasmodium, and eventually fusing in the plasmodium itself. He observed that many of the nuclei in the plasmodium remained free, but claims to have seen various stages of nuclear fusion. The free nuclei he considers to be those which have found no partner, and concludes that they will eventually degenerate.

He bases this statement, as to the haploid condition of the plasmodial nuclei, on his cytological observations. His figures show two masses of chromatin (which he calls chromosomes) passing to each pole in all divisions, whether in the plasmodium or in the swarm spores. His figures, however, are not very convincing. The chromosomes of the Mycetozoa are very minute and difficult to see, the chromatin masses which he figures are considerably larger in some divisions than in others, and it is quite possible that they are aggregates of, and not single chromo-

somes. Moreover, he was not aware that fusion of gametes takes place in the motile swarm-spore stage. Stained preparations of rounded off zygotes and swarm spores are always uninucleate, showing that nuclear fusion must have taken place.

This is not the first record of caryogamy in the plasmodium in the Mycetozoa. Kränzlin (17), working in Jahn's laboratory, observed paired nuclei (which she interpreted as caryogamy) in sections of very young sporangia of species of *Trichia* and *Arcyria*.

This pairing was followed by one reductional division "auf die Karyogamie sofort eine Reduktion folgt" before spore formation, and the second reduction division immediately after in germination of the spore. At that time, these observations led Jahn (1907) to believe that the $2n$ generation was of very short duration, not only in these two genera but in the Mycetozoa in general. Later, however (1911), he was able to count the chromosomes of *Physarum didermoides*, and found the nuclei of the swarm spores to be haploid, and those of the plasmodium diploid, showing the $2n$ generation to be of longer duration than he had previously thought.

Olive (19, 20) also claims to have seen nuclear fusions in the plasmodium of *Ceratiomyxa*, and Jahn (12) in his first paper on this species, also records nuclear fusions at this stage. Later, however (13), he owns he could find no general caryogamy in the plasmodium of *Ceratiomyxa* or in any other species he investigated, but surmises ((13), p. 348), from the condition of the nuclei in *Ceratiomyxa*, after emergence of the plasmodium from the wood, and from the presence of numerous degenerating nuclei, that caryogamy must have taken place shortly before within the substratum. In 1911, however, he came to the conclusion that the paired condition of the nuclei was a sign of degeneration.

Ceratiomyxa stands in a class by itself and differs from the Endosporae in that one mitosis occurs before spore formation (held by Jahn to be a reduction division), two mitoses during the ripening of the spore, and one after germination, resulting in eight swarm spores. Olive looks upon the two divisions in the ripening spore as the reduction divisions. Both these authors agree, however, as to reduction taking place before germination.

All other species of Endosporae which have been cytologically investigated, with the exception of *Dictyostelium mucoroides* and *Reticularia Lycoperdon*, show only one mitosis immediately before spore delimitation. In *D. mucoroides* Skupienski (24) observed a tetrad division before spore formation, each haploid nucleus forming the nucleus of a spore, and yet he describes fusion of myxamoebae and the development of plasmodia in

monospore cultures of this species. In *Reticularia Lycoperdon* (29) the first species of the Mycetozoa to be thoroughly investigated both cytologically and experimentally, Wilson and Cadman describe and figure typical meiosis, comprising two divisions before spore formation, and these authors suggest that, owing to the small size of the nuclei and the rapidity with which the two divisions follow one another, a second division may have been overlooked in other species of Mycetozoa.

If the tetrad division in *D. mucoroides* constitutes a true meiosis, then the spores are haploid, but the occurrence of plasmodia in mono-spore cultures suggests that the spores, although haploid, are bisexual, and that the differentiation of the sexes must occur at some subsequent division after the germination of the spore. It would be interesting to know if the spores of *Ceratiomyxa* and *Reticularia* are also bisexual.

As far as I am aware, *Ceratiomyxa* has not been grown in culture, and in *Reticularia* it appears that "autocatalytic" action is necessary for the germination of spores. Wilson and Cadman found that germination was very scanty or failed altogether when only a few spores were present.

In the other Endosporae, Jahn (14) states quite definitely that in *Physarum didermoides* and *Didymium effusum* the one mitotic division immediately before spore delimitation is a reduction division, and yet he found plasmodia in monospore cultures in the latter species.

Previous to his work on these two species, Jahn was of the opinion that the reduction process was initiated during the mitotic division before spore formation, and completed during the first division of the emerging swarm spore, the resting condition of the spore nucleus being interpolated between the two divisions. A similar conclusion was arrived at by Kränzlin with regard to species of *Arcyria* and *Trichia* (17).

There appears to be considerable doubt amongst recent cytologists whether it is possible for the reduction process to be completed in one division. Typical meiosis is generally held to comprise two divisions, during which each chromosome in the zygote nucleus has to be disjoined from its homologue, and divided equationally into two halves. The disjunctional or equational division of all the chromosomal units may take place either at the first or the second meiotic division, or in some units at the first and in others at the second. Recent experimental work has shown that in Fungi, heritable factors (such as the factors for sex in the Hymenomycetes) can either segregate at the first or the second division. There are indications also, although sufficient proof is not forthcoming as yet, that segregation may take place during both divisions.

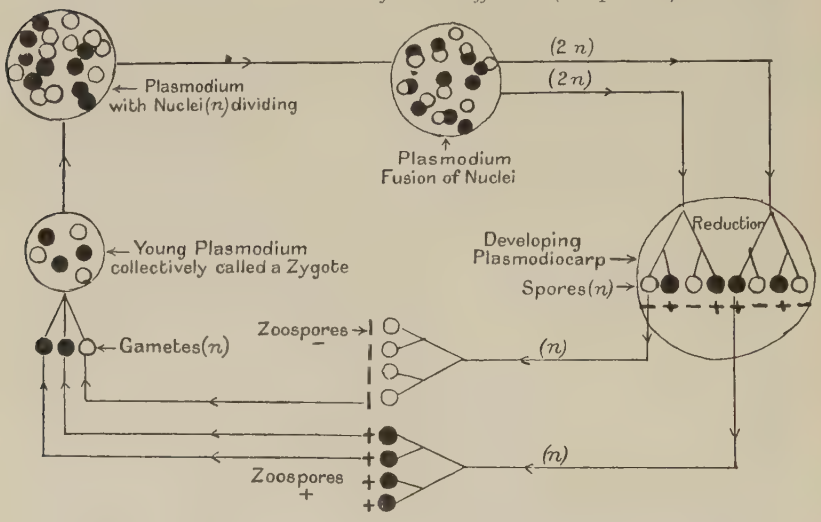
There is no doubt that in some Mycetozoa the number of separate chromatin masses is halved during the division immediately before spore delimitation, but the chromosomes may be double or bivalent, and the actual chromosomal units reduced at some subsequent division. In the present state of our knowledge, therefore, it is misleading to assume that reduction can be completed in a single division, and that the resulting spore nuclei are haploid. Experimental results have shown that sex segregation does not take place before spore formation in *D. difforme*, *D. nigripes* (see p. 230), *D. effusum*, *Dictyostelium mucoroides* and a species of *Physarum* (2) according to Buchet, worked with by Skupienski under the name of *D. nigripes*. When it does actually occur has yet to be shown. There is no experimental proof that the first division of the emerging swarm spore is the critical one as far as sex is concerned. Skupienski did succeed in isolating three single myxamoebae, in *D. nigripes*, but found no fusion in the progeny, and the cultures died; he was able however to get fructifications in a culture from a zygote. The myxamoebae here however had undergone a number of divisions before they were isolated and were not daughter cells from the first division after germination. Jahn (12) saw indications of the reduction in chromosome numbers at this first division in *Amaurochaete*, *Reticularia*, *Trichia*, *Badhamia*, *Stemonitis* and *Didymium*, and it was these observations which led him to believe that this division completed the process of reduction. As stated above, it is now known that meiosis occurs before spore formation in *Reticularia* (29).

If true meiosis occurs in *Dictyostelium mucoroides*, then sex segregation in this species is not genotypic but phenotypic, and takes place in a plasma definitely haploid.

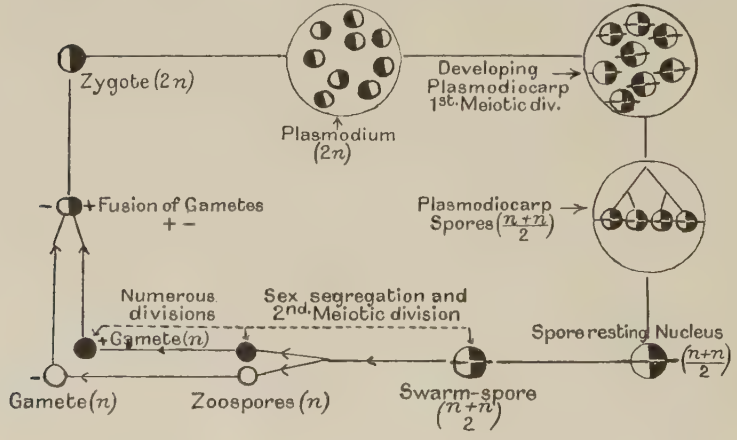
Jahn's observations (14) as to the necessary number of divisions of the swarm spores before the appearance of plasmodia, estimated by him to be twenty-eight in *Didymium effusum* but fewer in *Physarum didermoides*, and the present author's similar experience in *D. difforme* (although the number of divisions was not estimated) lend support to this view of haplo-phenotypic segregation. There is, however, another equally plausible hypothesis, namely, that the swarm spores require a certain period of growth and nutrition to attain sexual maturity. This point can be proved only by isolating and growing on the two daughter amoebae from the first division of the emerging swarm spore, a difficult and laborious task. On p. 246 two schemes are set out: (A) is Skupienski's scheme of the life-history of *D. difforme*, (B) the life-history of this species based on the experimental results described in this paper. The transverse line drawn through the circles representing the nuclei in (B) indicates that

the nuclei have undergone only one division, and are not completely reduced.

A. Scheme of life-history of *D. difforme*. (Skupienski).



B. Scheme of life-history of *D. difforme* (based on experimental results).



Summary.

Three species of *Didymium, D. nigripes, D. difforme* and *D. squamulosum*, have been grown in culture and have produced sporangia on a solid synthetic medium.

Some observations on the effect produced by external con-

ditions, more especially by moisture conditions, on the development of sporangia containing viable spores are discussed.

The fusion of gametes of *D. difforme* takes place in the motile swarm-spore stage.

The process of fusion, both in mono- and multispore cultures, as seen *in vivo* under the microscope, is described.

Plasmodiocarps have been obtained from three successive generations in monospore cultures of *D. difforme* on Knop agar.

These results prove that the spores of *D. difforme* are bisexual, and that sex segregation must occur at some division after the germination of the spore.

Our present knowledge of nuclear behaviour and sex segregation in the Mycetozoa in general is discussed.

In conclusion I wish to express my grateful thanks to Miss G. Lister for her unfailing and stimulating interest and advice and for her valuable help during the progress of the work, to Miss G. Waterhouse for her assistance during the last six months, and to Mr H. C. Osterstock for taking photographs for the plates.

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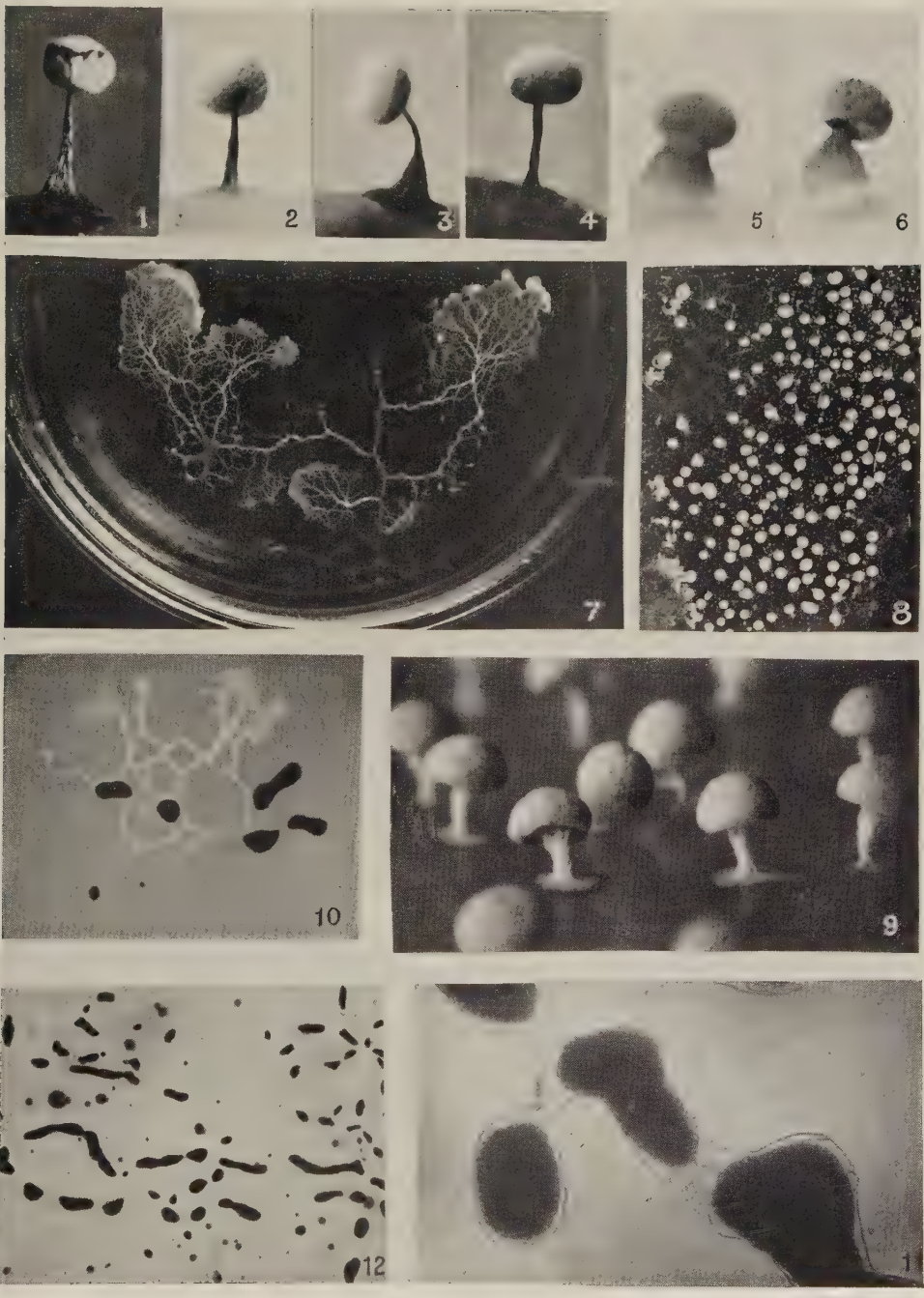
EXPLANATION OF PLATES.

PLATE V.

Fig. 1. Sporangium of *D. nigripes* on holly gathered in the open. × 20.
Fig. 2. Sporangium of *D. nigripes* on Knop agar-culture fifty-nine days old. × 20.
Fig. 3. Sporangium of *D. nigripes* var. *xanthopus* on holly infusion Knop agar. Monospore culture sixty-nine days old. × 20.
Fig. 4. Sporangium of *D. nigripes* var. *xanthopus*, same monospore culture as in Fig. 3, on sterile holly leaf. Sixty-nine days old. × 20.
Figs. 5 and 6. Same monospore culture as in Figs. 3 and 4 on Knop agar + 5 per cent. cane sugar.
Fig. 7. Plasmodium of *D. squamulosum* growing on the surface of Knop agar. Nat. size.
Fig. 8. Sporangia of *D. squamulosum* on lid of Petri dish containing Knop agar. Spores obtained from a sessile wild sporangium. Culture watered with Knop solution + 2 per cent. glycerine. Sixty-four days old. × 2.
Fig. 9. The same as Fig. 8, magnified to show typical stalks. × 20.
Fig. 10. Small plasmodium and plasmodiocarps of *D. difforme* on the surface of Knop agar. × 45.
Fig. 11. Plasmodiocarps of *D. difforme* developing in the strands of the plasmodium. × 80.
Fig. 12. Submerged plasmodiocarps of *D. difforme* beneath the layer of Knop agar on the base of the Petri dish. × 7.

PLATE VI. *Didymium difforme.*

Fig. 1. Young plasmodium in a monospore culture, dividing into chambers, showing colourless clear walls. × 1000.
Fig. 2. Abortive plasmodium in a monospore culture at a later stage, showing brown coloration of the walls of the chambers. × 1000.
Fig. 3. Completely aborted sporangium in a monospore culture. × 1000.
Fig. 4. Partially abortive sporangium in a multispore culture. *a*, *b*, *c*, apparently normal spores. × 1000.
Fig. 5. Four-spored sporangium in a monospore culture. × 1000.
Fig. 6. Eight-spored sporangium in a monospore culture. × 1000.
Fig. 7. Sporangium in a multispore culture, showing some monstrous spores and some normal spores. × 500.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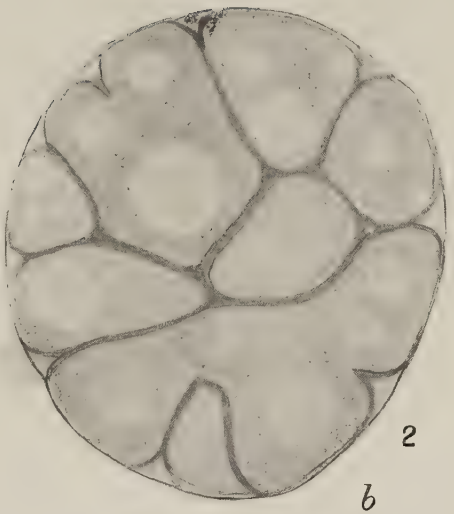

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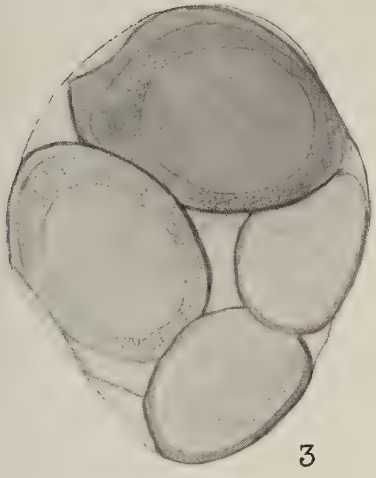

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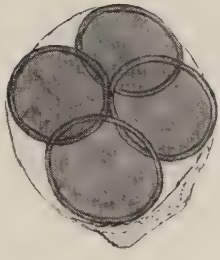

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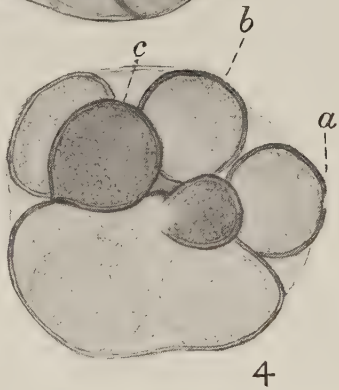

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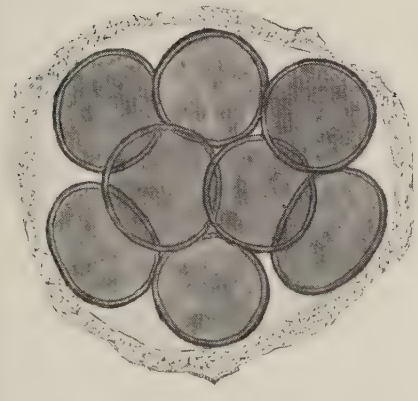

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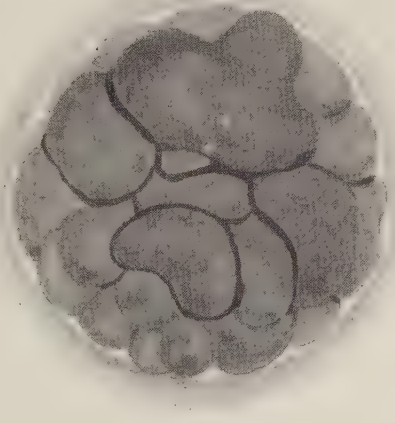

7

PHYTOPHTHORA PARASITICA DAST. CAUSING 'DAMPING OFF' DISEASE OF COTTONSEEDLINGSAND'FRUIT-ROT' OF GUAVA IN INDIA.

By M. Mitra, M.Sc., F.L.S., First Assistant to the Imperial Mycologist, Pusa, India.

(With two Text-figures.)

1. Phytophthora on cotton seedlings.

In August 1926 cotton seedlings growing at the Pusa Agricultural Research Institute were found to be attacked by a disease the initial symptom of which was the appearance of irregular water-soaked patches on the cotyledons and first-formed leaves. The diseased portions became devoid of chlorophyll and later developed a greyish colour, the main veins becoming light brown. The mature spots were surrounded by a yellowish green ring which gradually merged into the healthy green colour. Frequently several spots appeared on the same leaf and these by coalescing might involve the whole leaf. In severe attacks the infection spread to the petiole, with the result that the whole leaf hung down from its point of attachment to the main stem and finally dropped off. In half of the affected plants the growing point was finally invaded, with the consequent death of the seedling.

Table I. *Showing infection of cotton seedlings with* Phytophthora.

No. of seedlings inoculated	No. of seedlings infected	Remarks
6	6	Cultures used for inoculation were three days old
25	18	,, ,,
15	10	,, ,,
15	13	,, ,,
20	20	,, ,,
12	4	Cultures used for inoculation were eight days old
13	4	Cultures used for inoculation were fifteen days old
10	4	,, ,,

Microscopic examination showed the abundant presence in the affected parts—cotyledons, leaves, petioles and young shoots—of an unseptate mycelium. On the surface sporangia of the type of *Phytophthora* were found in large numbers. Isolations were made by picking off individual sporangia and plating on glucose-peptone agar. In other cases portions of affected

tissue were sterilised on the surface by the usual treatment with mercuric chloride (1 : 1000) and plated out in the same manner. Pure cultures of a *Phytophthora* (the same by either method) were thus obtained. Oat-meal and French bean agars were found to be suitable for the sporulation of this fungus.

Fig. 1. *Phytophthora parasitica* on young leaves of cotton-seedlings. × 1½.

Inoculations were made by placing pieces of mycelium together with sporangia on the unwounded surface of cotyledons, leaves, growing point, etc. of cotton seedlings. The latter, with uninoculated control plants, were kept in moist glass chambers. Table I gives the details of inoculations carried out. The control plants always remained healthy. The various tests were carried out in July and August of the years 1926 and 1927.

Altogether 68 per cent. of the inoculated plants became infected. The figures given in the table further suggest that a higher percentage (81 per cent.) of infection is obtained when

the inoculations are carried out with young mycelium and sporangia.

A limited number of inoculations were also made on plants bearing mature leaves and green bolls. About half of these inoculations on leaves and bolls were successful.

Fig. 2. *Phytophthora parasitica* on young leaves of cotton-seedlings. × 1½.

These experiments show that the *Phytophthora* concerned is able to attack cotton plants at different stages of their growth. This is the first reported occurrence of *Phytophthora* disease of cotton in India. Up to the present only seedling plants have shown the infection under field conditions.

2. Phytophthora on guava fruits.

Every year during the wet season (July–September) a fruit-rot disease appears on guava in the neighbourhood of Pusa. The fruits especially affected are those which have fallen to the ground or which hang near the ground level or which have been placed in storage. Diseased fruits show a superficial growth of woolly fungal mycelium which gradually spreads and finally covers the whole surface. The general external appearance of this disease is very similar to the "cottony leak" of various cucurbits caused by *Pythium aphanidermatum*. The fungus penetrates into the interior of the fruit, which is finally completely rotted.

Natural infection of healthy fruits is readily brought about by placing them in contact with diseased specimens. Within twenty-four hours water-soaked areas appear on the surface of the healthy fruits and two days later the whole of the latter may be covered with a profuse mycelial growth, while the fruit pulp has become brown and rotten.

Isolations of the fungus concerned, which proved to be a *Phytophthora*, were made in the usual way and a series of inoculations was carried out at different times. Altogether forty unwounded fruits were inoculated, and successful infection was obtained in every case.

Identity of the parasites.

The strains of *Phytophthora* from cotton and guava were compared in their morphological characteristics with a culture of *P. parasitica* Dast. isolated from castor oil seedlings. The writer also had access to a stock culture of *P. parasitica* and to spirit material preserved by Dastur and kept at the Pusa Institute. From these comparisons it was clear that all the fungi were identical, and agreed with Dastur's original description (3). In a recent paper Ashby (2) has extended the range of *P. parasitica* Dast. to include certain forms (*P. Nicotianae*, etc.) with larger oospores. The forms isolated by the writer are referable to the group *microspora* of *P. parasitica* Dast. emend. Ashby.

In order to confirm the above identification a series of cross inoculations was carried out. The main results are given in Table II.

From Table II it is clear that a high percentage of successful inoculations is obtained when the strain from any one host is placed under suitable conditions on any other. The parasitic range appears therefore to be the same throughout so that one is fully justified in considering the forms of *Phytophthora* from

cotton and guava as being identical with that occurring on the castor oil plant.

Table II. *Illustrating infective capacity of strains of* Phytophthora parasitica *obtained from different host plants.*

Source of fungus	Plant inoculated	No. of inoculations	No. of infections
Castor oil	Castor oil	51	36
	Cotton	98	48
	Sesamum	84	51
	Guava	35	35
Cotton	Cotton	116	79
	Castor oil	67	45
	Sesamum	68	36
	Guava	35	35
Guava	Guava	40	40
	Castor oil	47	43
	Cotton	72	60
	Sesamum	60	58

Previous records of *Phytophthora* spp. on cotton and guava.

Apart from the present instance, the only recorded occurrences of *Phytophthora* on cotton are from West Indies. Robson (7) in 1911 reported a soft rot of cotton on a variety of Sea-Island cotton in Montserrat. In 1917 Nowell (5, 6) described a disease of cotton bolls in St Vincent and Montserrat and stated that the casual organism in both instances was a *Phytophthora*. The disease was prevalent only during seasons with prolonged and heavy rainfall. The Phytophthoras causing disease of cotton in the various West Indian Islands were carefully examined by Ashby (1) in 1921. According to the latter, the form present in St Vincent resembles *P. palmivora* Butl. on coconut and *P. Faberi* Maubl. on cocoa (the latter probably being a strain of *P. palmivora*) while the forms from Montserrat and from Trinidad resemble *P. parasitica* Dast. Hopkins (4) in 1925 has described in detail the action of the three above-mentioned forms on different varieties of cotton, and bears out fully Ashby's diagnosis.

As has already been stated, the natural occurrence of *P. parasitica* on cotton in India has so far been confined to the seedling stage. The capacity of the fungus to attack green bolls under artificial conditions has been demonstrated by the writer.

The occurrence of *P. parasitica* on guava has been recorded only from India, and in this instance.

The cultures of all the three strains, viz. from cotton, guava and castor-oil plant, were submitted to Mr S. F. Ashby of the Imperial Bureau of Mycology, and my sincere thanks are due

to him for very kindly comparing the cultures and confirming the identifications.

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FURTHER NOTE ON THE PRODUCTION OF SEXUAL ORGANS IN PAIRED CULTURES OF SPECIES AND STRAINS OF PHYTOPHTHORA.

By S. F. Ashby, B.Sc., Mycologist, Imperial Bureau of Mycology.

(With two Text-figures.)

In two recent papers (1, 2) I have recorded the ready development of sexual organs when certain strains of individual species of the genus *Phytophthora*, and also when certain distinct species were grown together in paired cultures. The species concerned were *P. parasitica* Dastur (emend.), *P. palmivora* Butler, *P. cryptogea* Pethyb. and Lafferty, and *P. Cinnamomi* Rands. With the exception of the last-named, oospores have been found, although sometimes after long delay, in some pure single strain cultures of all the species; so that the individual mycelia would appear to be homothallic, and there seems to be no need for assuming that those strains are heterothallic in which oospores have been formed in paired cultures but not, as yet, in pure cultures.

Opportunity has been afforded also of examining isolations of *P. Arecae* (Colem.) Pethyb. and *P. Meadii* McRae. Coleman (3) obtained oospores of *P. Arecae* when pure single strain cultures were inoculated on shelled areca nuts, and Rosenbaum (4) and Leonian (5) have recorded them in pure cultures on agar media.

McRae (6) recorded oospores in pure single strain cultures of *P. Meadii* on agar media. At the instance of Dr McRae, an isolation of *P. Meadii* from *Hevea brasiliensis* in India, made some three years ago, and another from the same host in India, made about one year ago, were sent to me. An isolation of the same species, made this year from Black Stripe of *Hevea* in Malaya by Mr A. Thompson, has also been available. The culture of *P. Arecae* was obtained from the American Type Culture Collection in Chicago (No. 1401). Oospores were detected in scanty numbers after several months in maize meal agar cultures of the older isolation of *P. Meadii*, soon after it was received, but they were not found in later cultures; they have not been detected in cultures of the later isolations. The

Fig. 1.

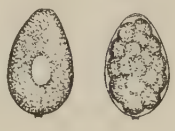

Fig. 2.

Fig. 1. Zoosporangia of *P. Cinnamomi*. × 345 (after Rands).
Fig. 2. Zoosporangia of *P. cryptogea*. × 510 (after Pethybridge and Lafferty).

isolation of *P. Arecae* has not developed oospores on any medium including maize, bean and quaker oats agars. When the strains of *P. Meadii* were grown together in pairs on maize-meal agar at 23°, sexual organs were not detected, but when each of the three isolations was grown with the strain of *P. Arecae* on the same medium at 23° C., sexual organs developed freely in four to five days. They were formed at first in the zone of contact of the two mycelia and later throughout most of the growth zone of the strain of *P. Meadii*, but were not present in the *P. Arecae* zone. The antheridia were amphigynous and after a few days the oogonia became thick-walled and golden-yellow; oospores developed but not in abundance, since the contents of the oogonia in many instances underwent an oily degeneration.

In Table I the dimensions in microns of the oogonia and oospores in the paired cultures of the strains of *P. Meadii* with

P. Arecae are shown, together with the data recorded by other observers on the two species in pure culture.

Table I.

Strains	Oospores Mean size	Oospores Range	Oogonia Mean size	Oogonia Range
P. Meadii (older isolation in India) + *P. Arecae*	24·0	20–28	28·5	24–34
P. Meadii (later isolation from, in India) + *P. Arecae*	25·8	18–29	—	—
P. Meadii (Malaya) + *P. Arecae*	25·3	20–28	29·0	24–35
P. Meadii (McRae's data)	25·0	16–32·8	32·0 (approx.)	22–45 (approx.)
P. Arecae (Coleman's data)	—	23–36	—	—
P. Arecae (Rosenbaum's data)	32·4	23–44	—	—

The size and distribution of the sexual organs in the paired cultures indicated, therefore, that they were actually those of *P. Meadii*. A comparison of the culture of *P. Arecae* with those of *P. Meadii* brought out no criteria sufficient to separate them as independent species.

The sporangia which are formed in sympodia freely in water cultures, are similar in size and shape with a papilla rather less prominent than in most strains of *P. palmivora*; a slender hollow pedicel is present several times longer than in *P. palmivora*. The mean size of the sporangia of *P. Arecae* on oat agar, according to Rosenbaum (*l.c.*) is 48 × 30 μ, and McRae (*l.c.*) records the same mean size for those of *P. Meadii* on french bean agar. I have not found chlamydospores in young cultures of either, but in old cultures resting spores may be present as terminal and mostly thick-walled papillate conidia. The larger recorded size of the oospores in *P. Arecae* does not in itself suffice to establish a difference of species. It seems highly probable that both are one species, separable by their behaviour in paired culture into two groups of strains—the "Arecae" and "Meadii" groups, comparable with the "cacao" and "rubber" groups of *P. palmivora* (*l.c.*). I hope soon, however, to be able to examine further cultures of *P. Arecae* both from the areca palm and from other hosts.

In an earlier paper(2) a brief reference was made to the development of sexual organs and oospores in paired cultures of *P. cryptogea* Pethyb. and Lafferty with *P. Cinnamomi* Rands. It may be of interest to record the data obtained in more detail.

One of the strains of *P. cryptogea* was sent by Dr G. H. Pethybridge, who had recently isolated it from a tulip; he sent also a piece of the flower stalk from which hyphae had grown out into water and had formed sporangia freely. The other strain was obtained from the Centraal-bureau at Baarn, Holland,

together with a culture of *P. Richardiae* Buis. isolated by Buisman(1) from the Calla lily. The culture of *P. Cinnamomi* was obtained from the American Type Culture Collection, Chicago (No. 1407).

The asexual spores of the strain from tulip, both the non-papillate zoosporangia and the flask-shaped conidia formed on the tulip stem in water, were quite similar to those described and figured by Pethybridge and Lafferty(6), and those obtained when mycelium from pure cultures of the tulip strain and that from Baarn were allowed to grow on sterilised centipedes in water were also quite alike.

When the two isolations were grown in paired culture with *P. Cinnamomi* on maize-meal agar at 23° C., sexual organs were found to be forming freely in the "cryptogea" zone after nine or ten days, and oospores matured in abundance a few days later; no sexual organs developed in the zone of growth of *P. Cinnamomi*, the mycelium of which can be readily distinguished by the abundant development of stalked, large, thin-walled vesicles occupied by one or more oil globules and produced terminally either singly or in bunches.

The tulip strain has not developed sexual organs in pure culture after six months, either in a cool cellar or in the laboratory on any medium, but they were present in rather scanty numbers in a pure culture of the strain from Baarn on maize-meal agar (but not on quaker oats or french bean agar) after six months in a culture kept in the cellar. The mature sexual organs were alike in the paired cultures and the pure culture, the antheridia being apparently always amphigynous, the oogonia with yellow walls, and the oospores with thickened colourless walls. The strain of *P. Richardiae* developed substantially larger sexual organs with amphigynous antheridia and mature oospores abundantly after a week or two in pure culture on quaker oats, bean and maize media, and, as was to be expected, formed them freely and quickly in the paired cultures with *P. Cinnamomi* but only in its own zone. Conidia of *P. Richardiae* were obtained also on sterilised centipedes in water cultures. They were non-papillate with a broad flattened apex and somewhat thick-walled, and there was no evidence of the production of zoospores. Those of *P. cryptogea* developed under the same conditions were also non-papillate, often with somewhat thickened walls and a broad flattened apex, but some were thin-walled and able to form and discharge zoospores; they were smaller and relatively broader than those of *P. Richardiae* but quite of the same type. In the water cultures of both species similar more or less spherical, thin-walled enlargements of the hyphae occurred separated by short hyphal bridges;

frequently the enlargements produced short branches which again formed subterminal enlargements. They were similar to the formations described and figured (Pl. XLVII, fig. 9) by Pethybridge and Lafferty (*l.c.*) but often of a more definite shape. Measurements of the oospores and mature oogonia in the paired and pure cultures are recorded in Table II and the dimensions of the conidia in Table III. It will be noticed that the conidia of both species developed from pure cultures in water on sterilised centipedes are smaller than those formed in water on hyphae growing out from lesions on the host. *P. Richardiae* differs from *P. cryptogea* in developing sexual organs and oospores more readily in pure culture, which although similar in development and structure, are substantially larger; the conidia of *P. Richardiae* are also larger and have a higher ratio than those of *P. cryptogea*; the greenish purple colour of the oospores of *P. Richardiae* recorded by Buisman (*l.c.*) was not seen in my cultures.

Table II.

Strains	Number measured	Oospores Mean size	Oospores Range	Oogonia Mean size	Oogonia Range
P. cryptogea (tulip) + *P. Cinnamomi*	50	24·6	20·5–29	29·2	24·8–34
P. cryptogea (Baarn) (*a*)	75	23·6	19–29	28·2	24–34
+ *P. Cinnamomi* (*b*)	24	23·1	19–29	—	—
P. cryptogea (Baarn) pure culture	33	23·0	19–28	27·5	24–32
P. Richardiae + *P. Cinnamomi*	55	31·0	24–36	38·5	32–43
P. Richardiae (pure culture)	100	30·7	19–41	39·0	29–48
P. cryptogea (Pethybridge and Lafferty)	—	25·0	—	30·0	—
P. Richardiae (Buisman)	—	± 29·0	—	—	± 34–38

Table III.

Strains	Conidia (Sporangia) Mean size	Ratio	Range
P. cryptogea (tulip) (flower stalk in water)	43·9 × 29·8	1·47	25–54 × 18–37
P. cryptogea (tulip) (pure culture in water)	32·3 × 22·8	1·42	20–42 × 16–29
P. cryptogea (Pethybridge and Lafferty)	40 × 27	1·48	24–50 × 17–30
P. Richardiae (pure culture in water)	41·7 × 26·2	1·59	24–66 × 18–33
P. Richardiae (Buisman)	—	—	—
P. Richardiae (Salmon and Ware) (11)	Commonly 52 × 33	1·58	—
P. Cinnamomi (Rands)	57 × 33	1·7	Commonly 38–84 × 27–39

The author's studies on the strains of *P. parasitica* Dast. (emend.) and *P. palmivora* Butler (*l.c.*) have led him to the conclusion that the essential similarities, apart from mere differences in the size of the conidia (sporangia) and sexual organs of *P. cryptogea* and *P. Richardiae*, do not justify a distinction of species, but that the differences are sufficiently recognised by recording it as a variety, namely *P. cryptogea* Pethyb. and Lafferty var. *Richardiae* (Buis.).

Zoosporangia of *P. Cinnamomi* have been developed also when mycelium from maize-meal and quaker oats agar cultures has been transferred to water which was changed a few times. They are non-papillate and similar to, but substantially larger than, those of *P. cryptogea* (see Table III), and discharge zoospores of the same size. Sexual organs have not been found in pure cultures, but those developed in a paired culture with a strain of *P. parasitica* (*l.c.*) showed amphigynous antheridia and oospores of similar size to those of *P. Richardiae*. The vesicles formed so abundantly on solid media are peculiar (Rands (9) calls them chlamydospores) and closely resemble the similar bodies developed on the same media by *Blepharospora cambivora* Petri, a culture of which was kindly sent by Prof. L. Petri. Sexual organs have not been detected in paired cultures of *B. cambivora* and *P. Cinnamomi* and the first has also not formed them in pure cultures. Sporangia of *B. cambivora* have developed in water cultures on sterilised centipedes; they show a more marked narrowing towards the broad tip approaching the papillate type, but the hyaline apical layer is relatively shallow. As Buisman has pointed out (*l.c.*), the proliferation of the pedicel with the production of new sporangia within those which have discharged zoospores and other characters indicate a close relationship of the four forms, but *P. Cinnamomi* appears to be nearer to *B. cambivora* than to *P. cryptogea*.

Pythiomorpha gonapodioides Peters (10) (for a culture of which thanks are due to Dr Westerdijk) has developed coloured thick-walled chlamydospores in culture; in paired cultures it grows vigorously, soon over-runs and suppresses any strain of *Phytophthora*, and no sexual organs have been detected in such cultures.

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THE PRODUCTION OF SEXUAL ORGANS IN PURE CULTURES OF PHYTOPHTHORA CINNAMOMI RANDS AND BLEPHAROSPORA CAMBIVORA PETRI.

By S. F. Ashby, B.Sc., Mycologist, Imperial Bureau of Mycology.

(With two Text-figures.)

In the preceding paper* on the production of sexual organs in paired cultures of strains and species of *Phytophthora* the statement was made that they had not been detected in pure cultures of *P. Cinnamomi* and *B. cambivora*. They have now been found in a pure culture of *P. Cinnamomi* (American Type Culture Collection, No. 1407) in two tubes of sloped maize-meal agar after six months at the temperature of the laboratory; and also in the "Cinnamomi" zone of a paired culture of that species with *B. cambivora* on the same medium and of the same age.

In one of the tubes of *P. Cinnamomi* alone, a yellowish brown patch, present on the glass at the base of the V, was found to be due to many mature sexual organs with large amphigynous antheridia which were mostly longer than they were broad. The oogonia, which showed more or less thickened yellow walls, although in some instances the coloured walls were quite thin, were for the most part broadly clavate with the wide funnel-shaped base within the antheridium. The oospores with hyaline thickened walls usually filled the upper main part of the oogonial cavity. The sexual organs appeared to be borne on separate hyphae. The measurements which follow, record in microns the

* See p. 252.

mean size and range of sixty-five oospores and thirty-two oogonia and antheridia.

Organs	Mean size	Range
Oospores	27·2	19–36
Oogonia	32·0	21–42
Antheridia	19 × 17	15–25 × 13–19

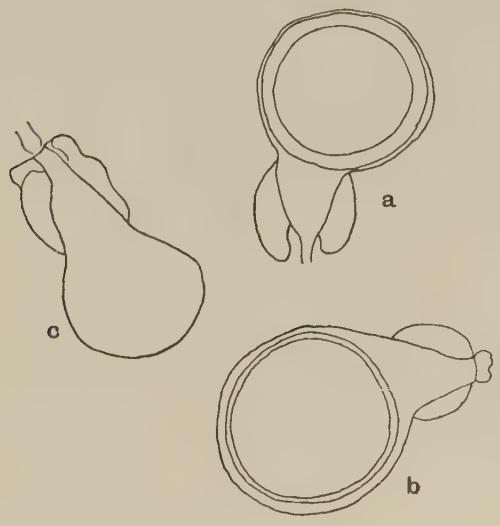

Fig. 1, *a* and *b*. Mature sexual organs of *P. Cinnamomi* showing oospores and amphigynous antheridia. × 700. *c*. Immature sexual organ of the same species. × 700.

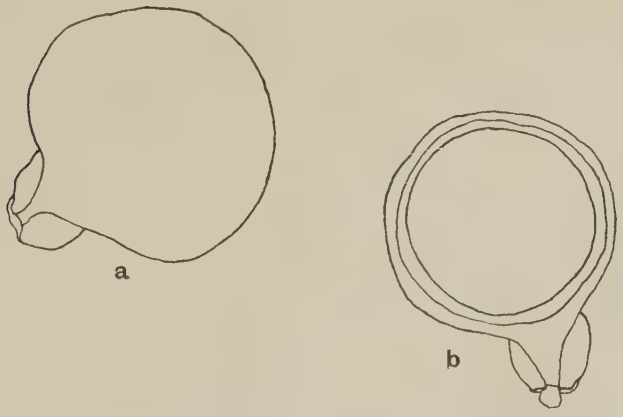

Fig. 2, *a* and *b*. Mature sexual organs of *B. cambivora* showing amphigynous antheridia. × 720. (The oospore of *a* collapsed and was omitted from the drawing.)

The oospores and oogonia show a considerably greater range of variation in size than those of *P. cryptogea* Pethyb. and Lafferty and *P. Richardiae* Buis. (*l.c.*) almost as great, in fact, as those two forms together, while the mean sizes are intermediate. The size and form of the mature sexual organs in the pure cultures of *P. Cinnamomi* confirm my inference that those found in paired cultures of the same isolation with a strain of *P. parasitica* of the section "microspora" ((1), fig. 6) were actually those of *P. Cinnamomi*. This finding induced me to re-examine a pure culture of *B. cambivora** nine months old on slanted maize-meal agar in which sexual organs had not been detected previously. Three mature sexual organs with yellow oogonial walls were found at the base of the **V** and were mounted in dilute potash solution. The antheridia appeared to be amphigynous, but their relations to the oogonia were not very distinct. They were transferred to concentrated lactic acid, one being lost during the manipulation. In that medium the remaining two showed the relations of the antheridia and oogonia (see figure) to be distinctly of the amphigynous type. (In one the oospore collapsed and is not shown in the figure.) The dimensions in microns of the oogonia and oospores measured in dilute potash solution were:

	Oospore	Oogonium
1	40·8	49·0
2	35·7	43·3
3	40·0	49·0

The first two are shown in the figure, that with the mature oospore being the second; in potash the oospore did not quite fill the oogonial cavity, but in lactic acid it filled the cavity, increasing in diameter to 38 μ, while the oogonium showed no perceptible increase in size.

Petri (2) has recorded oogonia 22–26 μ and oospores 20–27 μ in diameter in the tissues of chestnut seedlings (the oogonium in his Pl. IV, fig. 14 is about 36 μ in diameter). In a later paper (3) he stated that the antheridia were paragynous in the tissues of seedlings and figured an oogonium about 42 μ in diameter. It is possible, therefore, that the one type of sexual apparatus might be dominant in the tissues of the host and the other type in pure culture on artificial media such as maize-meal agar. The production of similar sexual organs in pure culture strengthens the view of the close relation between *B. cambivora* and *P. Cinnamomi*.

* The original culture was kindly sent by Professor L. Petri by the hand of Miss M. L. Yeo, then on the staff of the Imperial Bureau of Mycology. It proved to be a vigorous pure culture.

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STUDIES IN THE MORPHOLOGY OF DISCOMYCETES.

I. THE MARGINAL GROWTH OF APOTHECIA.

By E. J. H. Corner, B.A., Sidney Sussex College, Cambridge.

(With four Text-figures.)

The early development of the apothecium has been investigated in several Discomycetes. The manner in which the mycelial hyphae grow together, branch and intertwine around the archicarp to form the primary sheath, and the origin of the hymenium, are known in some detail. In the smaller apothecia with no other complication in development, as *Pyronema* and *Ascobolus*, it may be said that the hyphal system is fully known. But in the majority there must be a continual formation of new tissue at the margin of the hymenium, which is one of the chief means of growth of the apothecium. Few investigations have included this period of marginal growth and they are unfortunately incomplete. De Bary (1) has described in general terms the marginal growth of two species of *Sclerotinia*, and Brown (4) has made a diagram of the hyphal system of *Ciliaria scutellata*, but the way in which the hyphae at the margin grow and branch, that is, the working of the growing-point, is not clearly shown. These are apparently the sole examples, yet, oddly enough, de Bary states (*loc. cit.* p. 53), without reference, that several accounts have been given of the way in which apothecia "grow for a time by the formation of new elements in their originally involute margin": these I have been unable to trace. In more recent works on the morphology of Discomycetes there is barely, if any, allusion to the process, though the evolution of the apothecium may be discussed. But to what purpose may one compare even apothecia differing only in size in this respect without a knowledge of the mode of formation of new tissue? The object of this paper is to bridge this gap in the morphology of the group.

In the papers of this series, Boudier's nomenclature has been used (2).

Material.

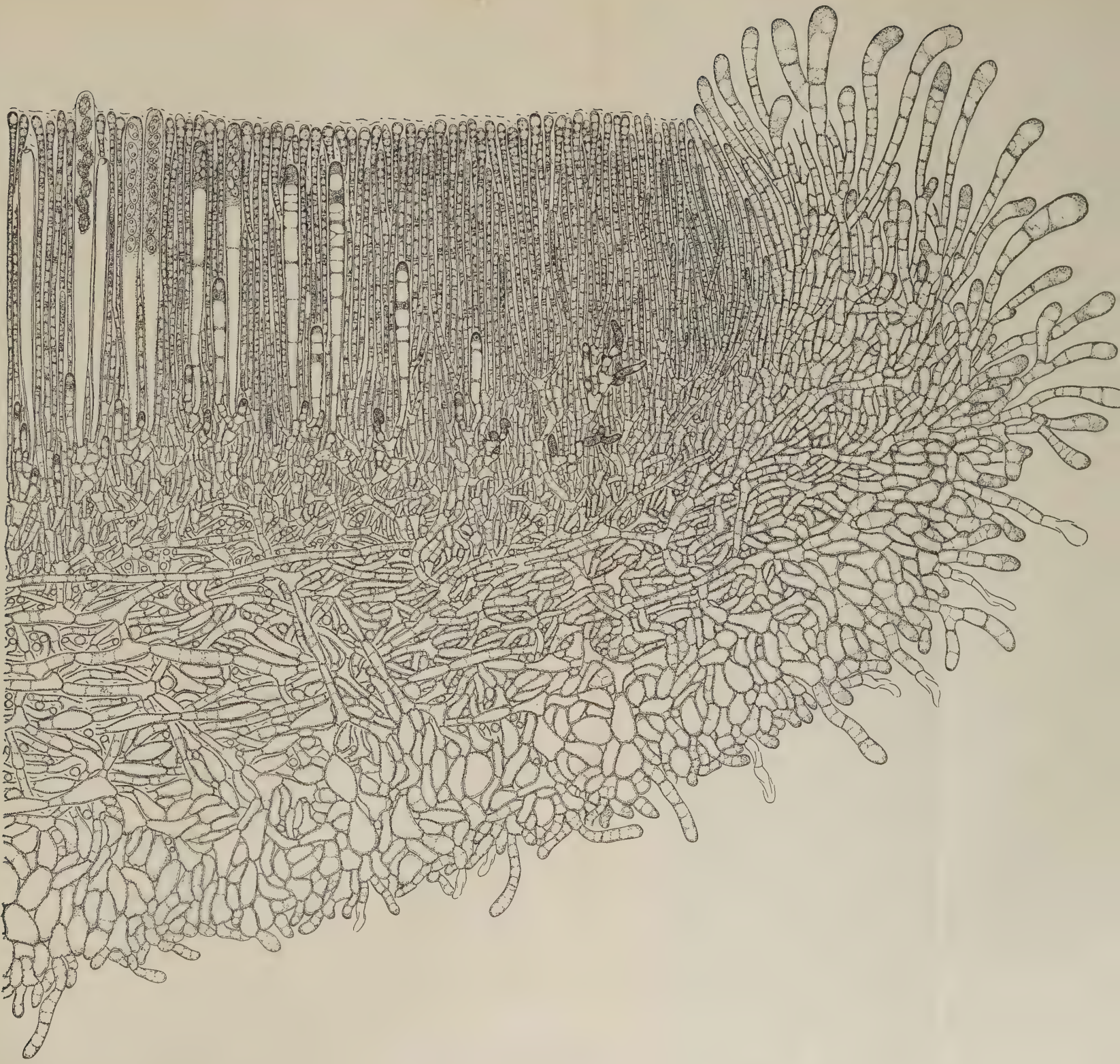
Only three species have been examined in detail, namely *Galactinia saniosa*, *Peziza aurantia* and *Coprobia granulata*, but I have also examined at one time or another the structure of the apothecium in a large number of species, ranging over most European operculate and several inoperculate genera. There is no reason to doubt that the process of marginal growth to be described is of general occurrence in both groups.

The best method of examining the growth of the hyphae and the origin of the tissues was found to be by means of freehand sections of living material. Owing to the transparency of the living tissue, the meandering course of the hyphae can be followed, merely by focusing in the section, to an extent which is impossible in microtome sections of fixed material. Such sections can also be kept for several months at least, with little deterioration by mounting them in dilute formalin. Moreover, protoplasmic detail is shown by the treatment of fresh tissue with iodine; the nuclei of spores and asci and even paired nuclei in the ascogenous hyphae can be seen clearly.

Description.

A radial section of any apothecium will show roughly a middle region of longitudinal hyphae, which can be traced from centre to margin, and a palisade layer on both sides, the hyphae of which can be traced to their junction with the longitudinal hyphae. The inside layer consists of narrow mucilage hyphae, the paraphyses, which with the asci form the *hymenium*, and the outside layer of hyphae with firm walls and inflated cells forming a pseudoparenchymatous *cortex*. The middle region may be called the *medulla*, and the region in which the ascogenous hyphae are situated, between medulla and hymenium, the *hypothecium*. Cortex and medulla may be referred to in combination as the *excipulum*. This is the usual notation except for the definition of the hypothecium. The term is used by different writers in varied sense and with little precision, for the medulla, or for a sub-hymenial layer of interwoven hyphae, or again for all the tissue between hymenium and cortex. But as here defined it is the only part of the apothecium containing ascogenous hyphae. The term trama is sometimes used instead of medulla, but, as defined by de Bary, it is better restricted to the tissue between two hymenial surfaces, *e.g.* in the complex hymenium of Morchellaceae, Tuberales, Agaricaceae, etc.

Only in the smaller apothecia is this construction obvious in



Text-fig. 1. Radial section of the margin of an apothecium of *Peziza aurantia*, 1 cm. wide; × 250.

the mature parts. It is diagrammatically clear in some of the Mollisiaceae, Ombrophilaceae, etc., but in the larger pezizoid apothecia, numerous secondary hyphae develop behind the margin, ramifying in all directions and, as it were, bind the components of the hyphal system together. Also differences in the rate of enlargement of tissues and individual cells may distort the main hyphae from their original course, and thus arises the interwoven structure of the sterile parts so common in mature apothecia and so meaningless until explained developmentally. The beginning of such a state can be seen in *Peziza aurantia* (Text-fig. 1).

At the margin of the apothecium the hyphae radiate more or less from the region where hypothecium and medulla converge. Those on the outside and inside of the marginal sheaf are of limited growth and are transformed into cortical hyphae and paraphyses respectively. The middle region is the main growing-point where new hyphae are continually produced. Now it might be thought that the hyphae in this region grow monopodially throughout development and that the laterals derived from them form cortical hyphae and paraphyses like the cortication of a multifilamentous alga. But this does not seem to be so. Apparently the apical growth of the hyphae is soon arrested and their place in the growing-point is taken by laterals which grow up from below to the surface to be in turn replaced, while the parts of the parent hyphae distal to the point of origin of the lateral mature into cortical and hymenial elements. Thus the hyphal system of the apothecium must be a sympodium: the distal parts of the marginal hyphae are continually pushed aside by the upgrowing laterals to form the two palisade layers and their intercalary parts, between adjacent laterals, constitute the medullary hyphae. The ramifications of any one sympodial system, *i.e.* that derived from a single hypha, are not confined to one palisade layer but may contribute to both, either initially by the separation of main laterals in the growing-point or subsequently by the growth of secondary laterals in the postmarginal region.

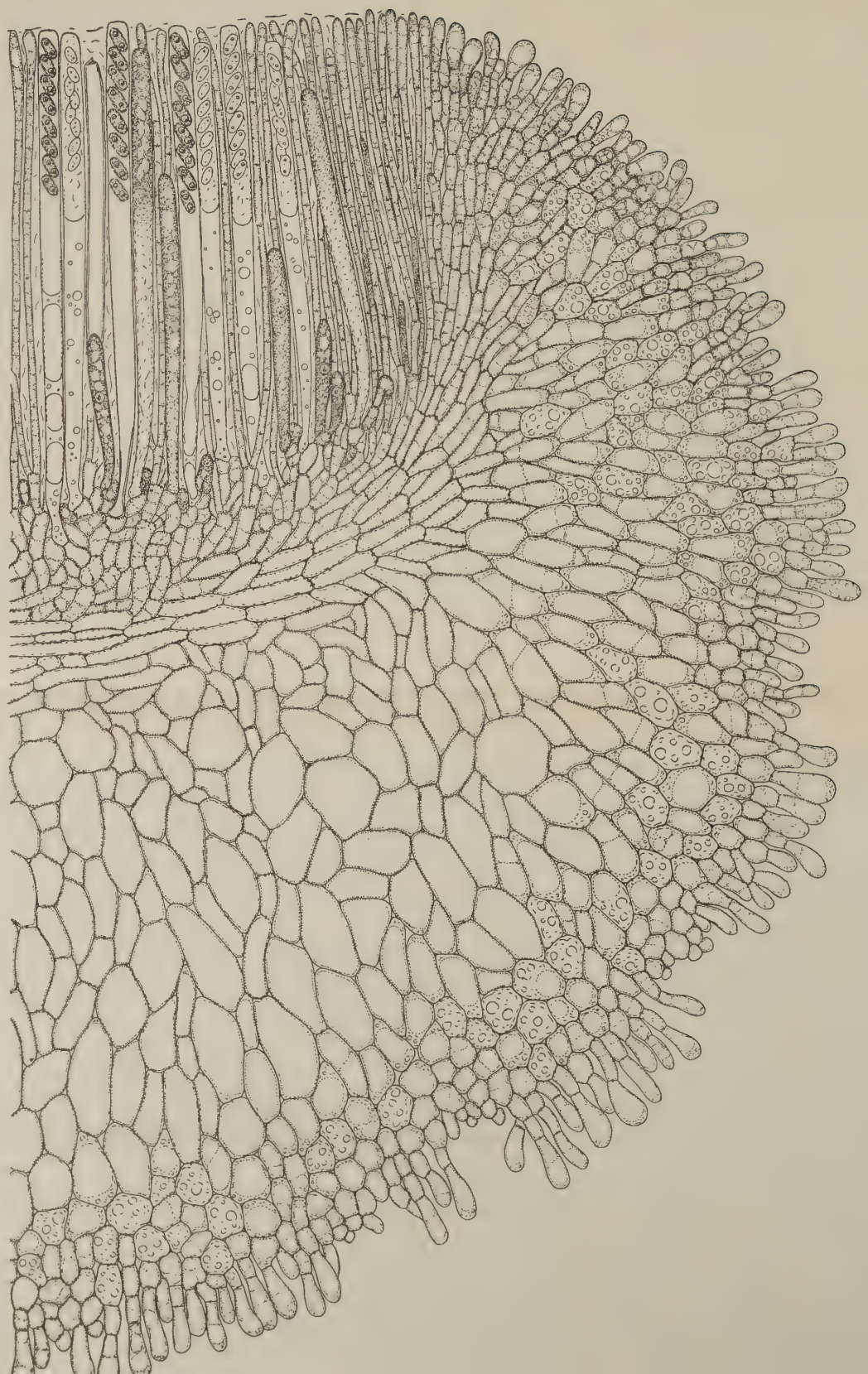
To watch the ramification of a single hypha in the growing-point was found impracticable, though it should not be impossible, and the conclusion, just given, is based on the following facts. Firstly, numerous laterals are to be found below the upper surface in the region between cortex and hymenium; they are narrow, 2–3 μ wide, as is normal for actively growing hyphae, and are obviously extending toward the surface. Secondly, these laterals have not developed the characteristics of cortical or hymenial elements whereas those which have reached the surface are evidently undergoing the necessary

modifications. Thirdly, the hyphae at the growing-point do not project beyond the general level of the hymenium; the level may even be lower in this part so that there is often a shallow sinus in the outline of the section, which would scarcely be expected if the hyphae formed a continuous monopodial system.

The modifications undergone by the hyphae in the marginal region depend on their position, whether on the outside or inside of the growing-point. It is convenient to consider them separately.

Paraphyses. The apical growth of the hyphae on the inside of the growing-point ceases on reaching the surface. The walls of these hyphae always become mucilaginous, providing the mucilage in which the hymenial elements are embedded. Other modifications vary in different species according to the characters of the mature paraphyses. In many, the cessation of growth proceeds equally on all sides of the apical cell so that the paraphyses are straight, but it may proceed irregularly when their tips are flexuous, or it may proceed regularly on one side before the other when they are more or less markedly hooked, *e.g. Otidea, Pulvinula.* Enlargement of the apical cell may also accompany cessation of growth, giving a characteristic clavate or capitate form to the paraphysis, as in the species figured. Rarely is there no enlargement and the paraphyses are then described as filiform. The subapical cells, however, generally remain narrow, 2–4 μ wide, forming the stalks of the paraphyses which, where the apex is enlarged, are separated from each other until pressed together by the developing asci: doubtless this loose arrangement of the stalks facilitates the intrusion of the ascogenous hyphae and asci into the upper palisade layer of the apothecium rather than the medulla or cortex. Still, occasionally, as *Aleuria* spp., the cells of the stalk may enlarge more than the apical cell, so that the hymenium appears pseudoparenchymatous, like the cortex.

Pigmentation is another peculiarity of the paraphyses. The pigment may occur in all the cells of the paraphyses or only in the distal cell or cells. It appears in the proximal cells usually before the hyphae have reached the upper surface in the growing-point, but not in the apical cell until upgrowth has ceased. The pigment may be in the form of granules and droplets, as the carotin of the humariaceous series, or dissolved in the cell-vacuoles, as the brown or purplish pigment of the Morchellaceae, Aleurieae, etc. Occasionally the paraphyses are filiform and unpigmented distally, *e.g. Neotiella Crozalsiana, Cheilymenia* spp., and it is obvious that they are merely paraphyses which have persisted in an immature state. The paraphyses of the Ascoboleae are unpigmented and clearly show their



character as specialised mucilage hyphae in the abundant formation of a yellowish hymenial mucilage.

On cessation of apical growth lateral hyphae, 2–3 μ wide, arise from the basal cells of the paraphyses; they grow to the surface of the hymenium when they undergo the same modifications. Generally, branching is confined to the proximal part of the paraphysis, but it may extend even to the apical cell. The epithecium, overlying the hymenium, which occurs in several inoperculate genera, Lichens and Tuberaceae, is formed by the profuse branching of the distal cells of the paraphyses together with their enlargement. It is the profuse branching of the basal parts of the paraphyses and the insinuation of ascogenous hyphae between them that causes the interwoven structure of the hypothecium.

In some apothecia, *e.g. Mitrula irregularis* and *M. vitellina*, according to Durand (6), there are no paraphyses. Their fewness can be explained by lack of branching in those formed at the growing-point, but their absence is a different proposition. It may be that in such apothecia there is no marginal growth, but there must be some means of providing the hymenial mucilage and support for the ascogenous hyphae.

Cortical hyphae. The hyphae on the outside of the growing-point are modified to form a firm resilient tissue supporting the hymenium on the underside of the apothecium. The walls of the hyphae do not become mucilaginous, and the cells enlarge, at least distally, and on slackening of apical growth numerous laterals are produced which grow between the primary hyphae. By these means the outer tissue is compacted into the pseudo-parenchymatous cortex.

Each cortical hypha has first a period of rapid growth. The rate of growth then declines, cortical modifications begin and the distal part of the hypha is splayed outwards and backwards by the upgrowth of new hyphae in the growing-point. Thus the cortex is formed at the margin of the apothecium by the continuous outward rotation of hyphae which are eventually placed on the underside of the apothecium, in contrast to the hymenium which is formed by their continued apposition.

The growth of the cortical hyphae may continue at a slow rate for some time, perhaps throughout the life of the apothecium, so that the excipulum continues to thicken behind the margin. There are two extreme courses; either the growth of a cortical hypha may slacken when the apex has reached the surface, or it may continue for some time so that the hypha projects beyond the general level of the surface. The first course occurs in *Galactinia saniosa* (Text-fig. 2), and generally in apothecia which are described as glabrous. The second occurs in all apothecia

which are piliferous and is illustrated by Brown for *Ciliaria scutellata*: the distal parts of the excrescent hyphae, being unbranched, form the hairs, while the cortex is composed of the branches from the basal parts. An intermediate condition is seen in *Peziza aurantia*, but in this species the distal parts of the excrescent hyphae remain thin-walled and collapse behind the margin.

The apical cells of the cortical hyphae enlarge first, and, as they may continue to grow, the cortical hyphae are frequently clavate, *e.g. P. aurantia*. But later the proximal cells may enlarge. In *G. saniosa*, and other Aleurieae, glycogen accumulates in these cells at the margin and disappears in the older parts of the cortex as the cells enlarge, which indicates an active turgescence like that of the ascus. In the Aleurieae the cortex is highly developed and forms a turgid layer, 2–4 mm. thick in the centre of the apothecium, composed entirely of inflated cells. In the specimens of *C. granulata* from which the illustration (Text-fig. 3) was made, the inflation of the cortical cells is remarkable; they enlarge from small cylinders, $25 \times 8\,\mu$, in the growing-point, to huge transparent vesicles 80–150 μ wide, and roughly a thousand times their original volume. In *P. aurantia* the cortex is poorly developed, though the cells may be 50 μ wide in mature parts.

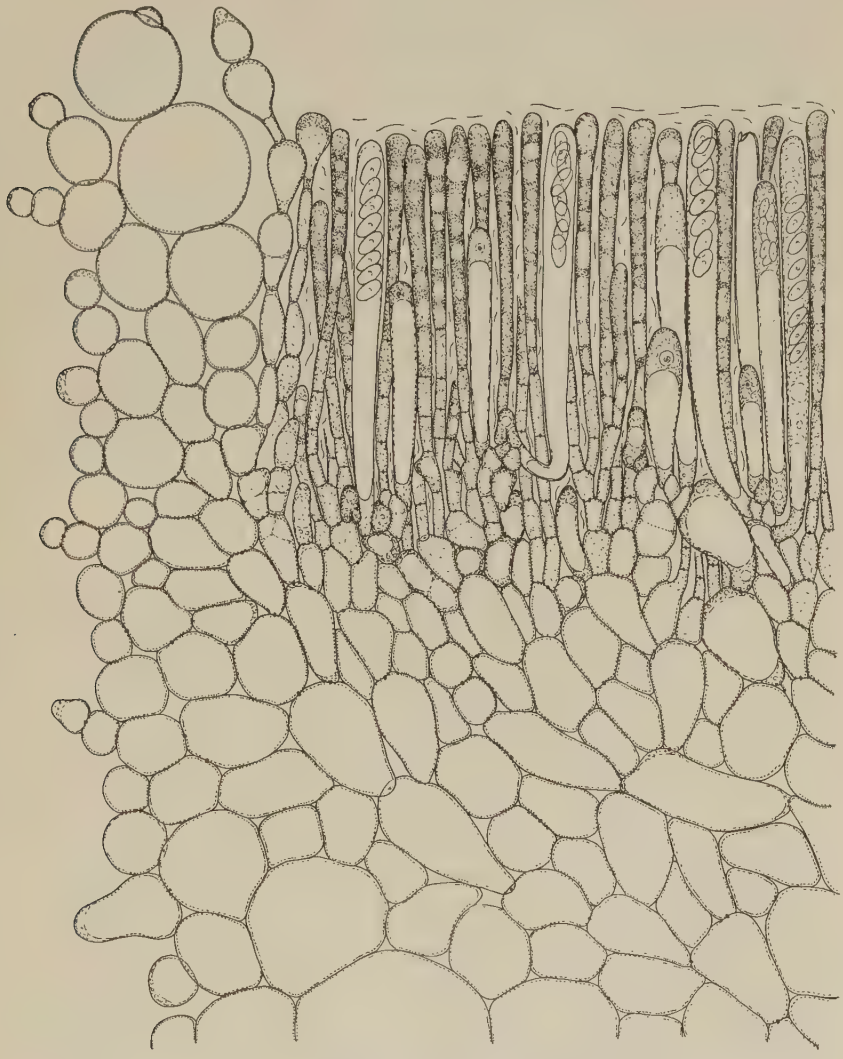
The production of laterals at the surface of the cortex behind the margin may keep pace with the enlargement of the internal tissue, so that the surface remains smooth, as in *P. aurantia*. But in most apothecia with a well-developed cortex, enlargement is excessive and the surface pile of hyphae is split into groups and tufts, which make the squamules, verrucae, pulverulence, villosity, etc. of specific descriptions. The beginning of such a process can be seen in the illustration of *G. saniosa*.

The palisade construction of the cortex persists at maturity only occasionally where branching and inflation of the cells is not great, *e.g. Helvella*, but generally these processes obscure the arrangement of the hyphae except at the surface.

The incurvature of the hyphae in the growing-point may be very marked, *e.g. C. scutellata*, and is due to the compression of the immature hymenium by the expanding cortex.

Medulla. The medullary hyphae produce secondary laterals behind the growing-point. The laterals may grow in any direction, into the hymenium where they give rise to tufts of paraphyses, into the cortex where they form cortical hyphae, or in the medulla, twining between the primary hyphae from which they can be distinguished only by tracing development. The cells of the medullary hyphae may enlarge and form a pseudoparenchyma continuous with the cortex, *e.g. C. granulata*, or

there may be only a sporadic swelling of the cells, or little enlargement, with the retention of the original filamentous con-

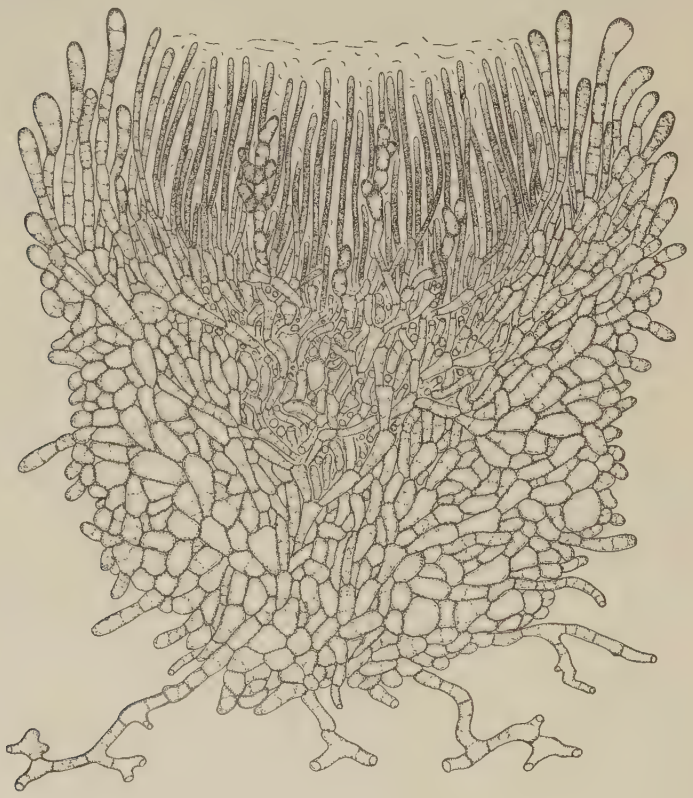


Text-fig. 3. Similar section from an apothecium of *Coprobia granulata*, 1·5 mm. wide; × 250.

struction, *e.g. P. aurantia*. When there is no active enlargement of the cells the expansion of the palisade layers exerts a tension,

which is chiefly radial, on the medullary hyphae, stretching the cells to a considerable length, 300 μ and more.

Origin of marginal growing-point. Text-fig. 4 shows a section through a very young apothecium of *P. aurantia*, which is growing in all its parts. The hymenium already appears to be formed, but, actually, those hyphae which are arranged in a palisade layer and resemble paraphyses, being pigmented to



Text-fig. 4. Median section of a young apothecium of *P. aurantia*, 350 μ wide; × 250.

some extent, are growing apically and branching monopodially; moreover, the ascogenous hyphae are about 50 μ below the surface, whereas they are situated some 200–300 μ internally in the mature apothecium. The upgrowth of the palisade layer continues for a longer or shorter time, which determines the height of the hymenium above the substratum. The cortical hyphae at the margin are also growing upwards, though it is clear that they already form a sympodium, being replaced by

laterals on the inside and rotated to the outside. Over the rest of the surface the hyphae are growing outward, some at a greater rate than others, to form secondary mycelial hyphae. When the upgrowth of the palisade layer is arrested, the formation of the hymenium begins, spreading centrifugally, and the sympodial growth of the hyphae between cortex and hymenium continues as the marginal growing-point of the apothecium. In *Helvella* and other genera with stipitate apothecia the general upgrowth of the primordium lays down a stem-region before any terminal expansion begins, and the stem is covered with a cortex in the same way as the outside of the apothecium.

Unfortunately, earlier stages could not be found, and the hyphal system could not be traced from its origin; from other accounts it appears that the cortical hyphae form a sympodium from the first.

Ascogenous hyphae. The formation of asci begins shortly before the cessation of upgrowth of the palisade layer, but the ascogenous hyphae continue to spread radially between the bases of the paraphyses. In large cupular apothecia they may lay 1–2 mm. behind the margin in early stages of development, but as marginal growth slackens they eventually reach the junction of cortex and hymenium. In the illustrations of *G. saniosa* and *C. granulata* marginal growth has almost ceased, but in *P. aurantia* it still continues actively and the ascogenous hyphae are some distance behind.

Growth of the hypha. The growth of every hypha in the apothecium is apical in that new cells arise by the formation of septa in the apical cell only; subdivision of intercalary cells has not been seen. The apical cell thus controls the growth of the hypha, and it is the apical cell which is most modified on cessation of growth, as witness the bizarre forms of paraphysis. Cessation of growth is usually accompanied with enlargement of the apical cell. In the cortical hyphae of *C. granulata* it is chiefly its proximal part which enlarges, the distal part remaining as a small boss or papilla filled with dense cytoplasm; a septum may form between the papilla and vesicular part and thus arise the minute lenticular cells on some of the terminal vesicles.

The formation of septa can be followed with comparative ease in the living hypha of the large "hairs" of *P. aurantia*. The septa are ingrowths from the cell-wall and, as described by Meyer (7), are apparently incomplete, for a narrow strand of cytoplasm is left which communicates between adjacent cells. Certain granules, or droplets, which have frequently been described but which, according to Cutting (5), are of unknown nature, appear on either side of the septum. There were usually four such granules, two on each side of the septum, in the three

species I have examined. Their presence greatly facilitates the unravelling of the hyphal system, for where the tissue is dense and the hyphal walls are contiguous the granules indicate the position of the septa.

Laterals usually arise from the distal end of a cell; as many as six have been found connected with a single cell in *P. aurantia*.

Discussion.

The rate of growth of a hypha in the growing-point rises from zero, on its origin as a lateral, to a maximum and then falls to zero again. The fall is associated with the production of laterals and the rate of fall depends on the position of the hypha. Such an association of fall in growth-rate and branching has also been observed in the mycelium of *Botrytis cinerea* by Smith (8) who concludes that it is due to the mode of nutrition of the growing apex. He considers that apical growth is initially proportional to the absorbing surface of the hypha, that is, to the amount of food entering the hypha, but when a certain length has been reached, the older part of the hypha is too far removed to contribute materially to the apex, and laterals arise in the older part as food accumulates. A similar process may occur in the apothecial hyphae, but with the simplification that they are always fed from below. Reserves are evidently stored in the hypothecium and medulla for the hyphae have usually fairly dense cytoplasm and are often full of glycogen. Furthermore, it is the tissue which nourishes the ascogenous hyphae, the older parts of which are devoid of protoplasm and cannot therefore take part in the conduction of food from the base of the apothecium. Considering the supply of food to the apex of a hypha which has just arisen in the growing-point and assuming the concentration at the apex to be zero, the concentration-gradient from the medulla to the apex is at first high but falls as the hypha lengthens. Eventually it becomes so low that the apex reaches the limit of the nutritional range of the medulla; apical growth then ceases and a lateral can arise at some point nearer the medulla where food accumulates. Thus the nutritional arrangement of the apothecium may cause the sympodium at the marginal growing-point.

Similarly the fall in growth-rate of the margin may be due to the fact that the margin eventually reaches the limit of the nutritional range of the mycelium, reckoned from the point of attachment.

But more obscure than the individual growth of the hyphae is the nature of the forces which combine them into the different tissues. Brief discussion of the more striking points will serve to emphasise this. Firstly, the direction of the hyphae in the

growing-point is always more or less perpendicular to the surface of the hymenium. Secondly, the ascogenous hyphae are restricted to the base of the hymenium where they spread radially, but the asci always grow toward the surface. Apparently there is no record of the growth of the ascogenous hyphae or of the asci into other parts of the apothecium. Thirdly, the hyphae in the growing-point are always modified in such a way that paraphyses are formed on the inside and cortical hyphae on the outside. Paraphyses are never found in the cortex, though admittedly what appear to be isolated cortical hyphae may be found in the hymenium, *e.g. Aleuria* spp. Fourthly, in such fruit-bodies as the basidiocarps of Agaricaceae the abnormal production of a hymenium in a sterile part is not infrequent, but there is no instance of a similar proliferation producing a hymenium on the outside of the apothecium. Abnormal proliferations of the hymenium may however occur, the most extraordinary perhaps being that of *Galactinia proteana* var. *sparassoides*, figured by Boudier (3); the fruit-bodies are a medley of partial apothecia produced by the confused action of several marginal growing-points.

With regard to the first point, no external stimuli appear effective, neither gravity nor light; apothecia may be formed on all sides of a lump of earth or a dead branch without geotropic or heliotropic curvature, and in large apothecia the orientation of the margin changes continually throughout development, even through nearly 180° owing to incurvature. Apparently the laterals in the growing-point simply grow in the direction of the parent hypha which is at first away from the substratum. But the action of light may be important in connection with the second and fourth points. The hymenium is always on the side facing the incident light, as in the hollow ascocarps of *Helvella*, *Morchella*, etc., where the inside of the fertile part is covered by a cortex like that of the stem and not by a hymenium. It is known that mature asci may be heliotropic and this property may direct their growth in the hymenium, though, as already suggested, they may simply take the path of least resistance in the mucilage between the paraphyses. In connection with the third point, the modification of the hyphae may depend on whether they grow into the hymenial mucilage or into the sub-saturated air surrounding the apothecium. But only experiment can solve such problems.

Lastly, the apothecia of *Rhizina inflata* must be mentioned, as they provide the one exception to the sympodial system which I have found. The brown hymenium is bordered by a white villose zone, 1–2 mm. wide, which is the marginal growing-point. A radial section of the margin shows the characteristic fascicle

of hyphae of which those on the inside, inclined upwards, are of limited growth, 3–4 μ wide, and are transformed into paraphyses, while those on the outside are also of limited growth but inclined downwards, 5–10 μ wide, and are transformed into cortical hyphae. In the comparatively broad intermediate region the hyphae are 3–5 μ wide and evidently grow apically throughout development; the hyphae apparently form a dorsiventral monopodial system. But the apothecia of *Rhizina* differ in many ways from the ordinary fruit-body of Discomycetes.

Summary.

The sterile tissue of the apothecium consists of two palisade layers, cortex and hymenium, and an intermediate medulla of radial and interwoven hyphae.

Marginal growth is performed by a fascicle of hyphae between the cortex and hymenium. Every hypha in the growing-point arises as a lateral, 2–3 μ wide, the growth-rate of which rises to a maximum, then falls, the fall being accompanied by branching in the proximal part and maturing of the distal part. The distal parts are transformed on the outside of the growing-point into cortical hyphae, on the inside into paraphyses; the proximal parts form the medullary hyphae. The hyphal system is therefore a sympodium.

The growth of the inner hyphae ceases on reaching the surface of the hymenium, but that of the outer hyphae continues for some time at a slow rate: "hairs" are cortical hyphae with a prolonged period of rapid growth.

The hymenium is formed at the margin by the apposition of hyphae, the cortex by apposition and outward rotation.

Paraphyses are specialised mucilage hyphae which are commonly pigmented. Cortical hyphae have no such pigment and are not mucilaginous; the enlargement of their cells forms characteristically a pseudoparenchyma supporting the hymenium.

An explanation of the sympodium at the growing-point is given on the assumption that the apices of the hyphae are fed from the medulla and eventually reach the limit of its nutritional range. Other points in the construction of the apothecium are considered.

The hyphal system of the apothecium of *Rhizina inflata* is exceptional, for it is evidently a monopodium.

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STUDIES IN THE MORPHOLOGY OF DISCOMYCETES.

II. THE STRUCTURE AND DEVELOPMENT OF THE ASCOCARP.

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(With seven Text-figures.)

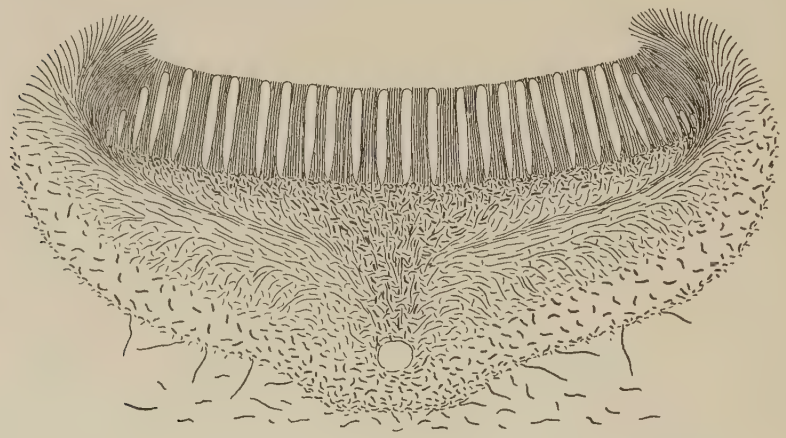
Morphology in fungi is a science of the development of hyphal systems. In the ascocarp there are two principal systems, one of which is gametophytic and the other sporophytic. Attention has been given hitherto mainly to the sporophytic system and that of the gametophyte, which builds the ascocarp, is largely without developmental interpretation, although the mature structure has been investigated in a number of Discomycetes, notably by Durand (15) and Lagarde (19). In the present paper an attempt is made to describe the development of the gametophytic system and to relate on such lines the different forms of monaxial ascocarp.

The material for this study has been gathered in great part from the accounts which have already been given by other investigators, chiefly on operculate species; the facts have been confirmed for the commoner genera as *Ascobolus*, *Pyronema*, *Humaria*, etc.

Sessile apothecia.

In Text-fig. 1 the construction of a sessile apothecium is shown diagrammatically. The hyphae are represented by short lines the direction of which indicates the course of the main

hyphae in the different tissues. The ascogenous hyphae are represented by short thick lines diverging from the ascogonium which is drawn as a circle near the base of the apothecium solely for reference; actually it is obliterated by the growth of the surrounding tissue at an early stage in development. Asci are drawn in successive stages of development at the margin of the hymenium to indicate the radial growth of the ascogenous hyphae, but no attempt has been made to show similarly their intercalary growth. The cortical pseudoparenchyma is shown by means of thick, well-spaced lines without special direction except at the margin, for the palisade arrangement is commonly lost in the mature tissue.



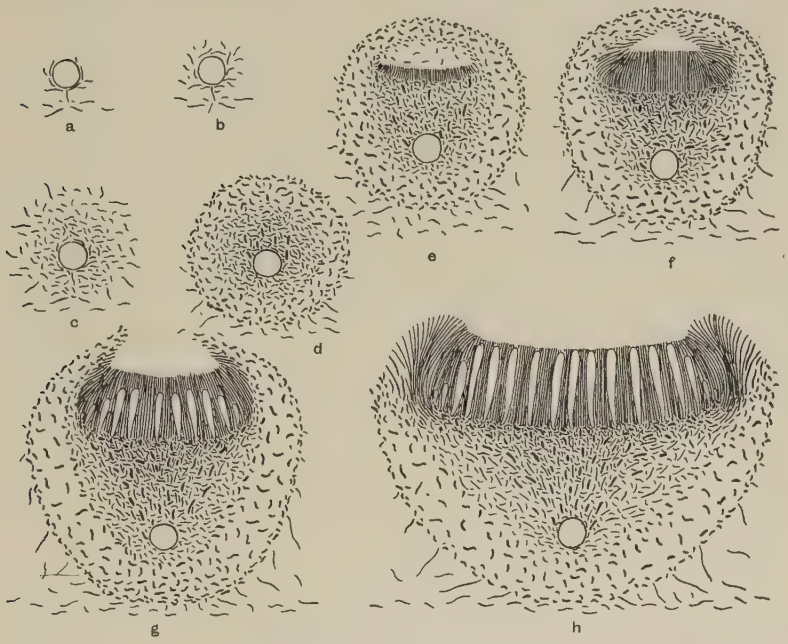
Text-fig. 1. Diagram of the construction of a sessile apothecium.

The construction will be obvious from the account of the marginal growth of apothecia. Mention should be made, however, of the secondary mycelium. It is composed of hyphae which grow from the underside of the apothecium, as excrescent cortical cells, into the substratum where they ramify as ordinary mycelial hyphae, 2–5 μ wide; to what extent they nourish the apothecium is not known. The secondary mycelium is restricted to the part of the apothecium in contact with the substratum, and if the apothecium is immersed it may be developed over the whole surface, *e.g.* the tomentum of *Sepultaria*. All structural transitions between secondary mycelial hyphae and "hairs" occur in the basal part of pilose apothecia.

The development of a sessile apothecium may follow one or other of two extreme courses, or it may take a middle course. It may be angiocarpic, the hymenium being formed within a mass of interwoven hyphae, called the primary sheath, or

gymnocarpic, when the hymenium is superficial from the first. The middle, hemiangiocarpic, course can best be explained after a description of the two extremes.

Angiocarpic development is shown diagrammatically in Text-fig. 2. The same notation is used; the ascogonium collapses about the time when the asci appear. In the first stage (*a*), sterile hyphae arise from the stalk cells of the archicarp or from adjacent mycelial hyphae and envelop the ascogonium in a loose weft, stage (*b*). The hyphae branch profusely, especially

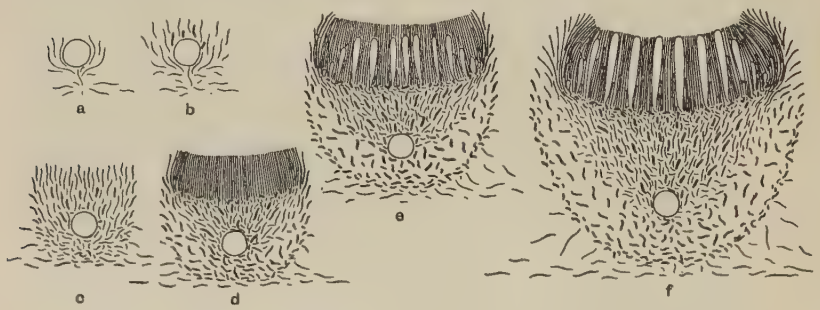


Text-fig. 2. Diagram of the development of an angiocarpic apothecium.

to the inside, which suggests a sympodium, and the branches apparently grow in all directions so that a ball of interwoven hyphae with the ascogonium near the centre results, stage (*c*). Then tissue-differentiation begins, stage (*d*). The cells of the outer layers enlarge and often become rather thick-walled, forming a pseudoparenchymatous cortex, while the internal hyphae remain thin-walled, and continue to branch, so that the spaces which would be formed by the expansion of the cortex are filled. A mucilage cavity then forms in the upper part of the spherical mass internal to the cortex, stage (*e*). It originates partly by the stretching of the internal tissue but mainly by the dissolution of the internal hyphae. Numerous

hyphae grow into the cavity as a palisade layer which spreads from the floor over the sides to the roof. Some hyphae are outgrowths from the cells lining the cavity, but others are said to originate from the neighbourhood of the ascogonium and to grow up with the ascogenous hyphae. The ascogenous hyphae are produced from the ascogonium after its envelopment and on reaching the floor of the cavity begin to form asci. The upgrowth of the palisade hyphae is soon arrested and they are transformed into paraphyses, which act marks the beginning of the hymenium, stage (*f*).

Subsequently the cortical layer overlying the mucilage cavity is ruptured by the expanding internal tissue, and about the same time the first asci are formed. The intercalary growth of the hymenium, due to the production of asci and paraphyses, presses the sides of the apothecium apart, exposing the disc, while the apothecium passes through a characteristic turbinate shape before becoming lenticular.



Text-fig. 3. Diagram of the development of a gymnocarpic apothecium.

Finally, in stage (*h*), a marginal growing-point is formed, and apparently from the hyphae which grew from the sides of the mucilage cavity and which, on exposure of the disc, form a sympodium: the outer laterals are converted into cortical hyphae and the inner ones into paraphyses.

Evidently primary and secondary parts can be distinguished in the angiocarpic apothecium. The primary part consists of the archicarp, the investing hyphae and the initial part of the hymenium and the primary period of development comprises all stages up to (*g*) (Text-fig. 2). The secondary part consists of all tissues derived from the marginal growing-point and the secondary period of development extends from the initiation of marginal growth to maturity.

Gymnocarpic development, shown in Text-fig. 3, is simple and direct compared with angiocarpic. The initial stages, (*a*)

and (*b*), are identical, but the investing hyphae do not form a closed sheath; they continue to grow upward as a palisade layer which becomes better defined as new elements are added from below, as in stages (*c*) and (*d*). The thickness of the apothecium depends primarily on the extent of this upgrowth, and on its cessation, first in the centre, the distal parts of the hyphae mature into paraphyses. Thus the formation of the hymenium is started and continues centrifugally till maturity. About the same time the cells in the lower part of the primordium begin to enlarge: the process extends outward and upward to the margin, forming a pseudoparenchymatous cortex. The ascogenous hyphae arise about stage (*b*), and grow upward with the sterile hyphae; the formation of asci begins shortly after the appearance of the paraphyses, stages (*d*) and (*e*).

The formation of the hymenium marks the end of the primary period of development which is characterised here by the growth of the main hyphae of the primordium away from the substratum. The secondary period, as in angiocarpic development, is that of marginal growth, and the growing-point must originate likewise from the junction of cortex and hymenium, but in both cases the details are obscure.

In hemiangiocarpic development hyphae arch over the ascogonium, but they are of limited growth and do not form a closed sheath. On cessation of growth they are apparently modified into cortical hyphae and they branch mainly to the inside. The laterals appear to repeat the sympodium next the cortex, but those in the centre of the whole structure, overlying the ascogonium, grow upward for some time and branch monopodially, as in gymnocarpic development, before they are transformed into paraphyses. This sheaf of internal hyphae pushes the cortical hyphae aside and so displays the disc. The sympodium at the junction of cortex and hymenium then continues as the marginal growing-point.

Of Operculeae with hemiangiocarpic apothecia may be cited *Cheilymenia stercorea* (Fraser (17)) and *Anthracobia melaloma*, *Ascophanus granuliformis* and probably *Peziza aurantia*, according to my observations: with angiocarpic apothecia may be cited *Coprobia granulata* (Blackman and Fraser (3)), *Ciliaria scutellata* (Brown (4)), *Ascophanus carneus* (Cutting (9)), *Ascobolus stercorarius* (Janczewski (18)), *A. carbonarius* and *A. Winteri* (Dodge (11)), *A. citrinus* (Schweizer (24)), *A. immersus* and probably *Saccobolus violascens* (Dangeard (10)), *Rhyparobius* (Dangeard (10)), (Barker (1)) and *Thelebolus* (Ramlow (22)): and with gymnocarpic apothecia, *Ascobolus magnificus* (Dodge (13)), *Pyronema confluens* (Claussen (6)), *Ascodesmis nigricans* (Claussen (5)) and perhaps *Rhizina inflata* (Fitzpatrick (16)), although in this

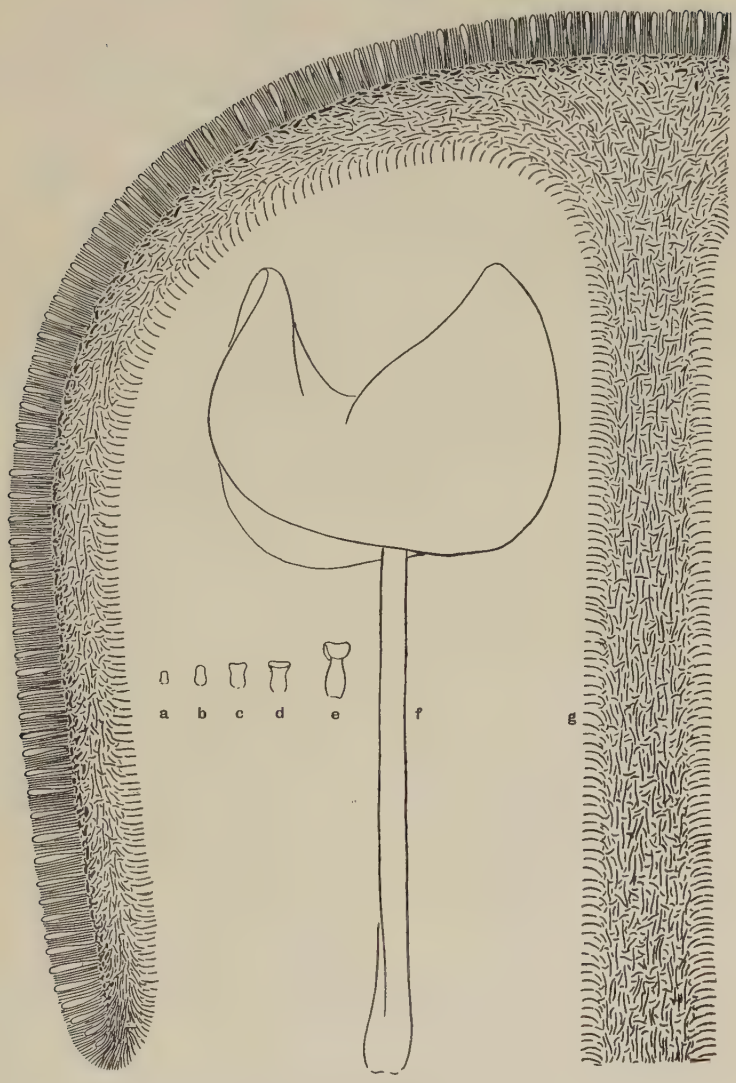
fungus the apothecia are more like the stipitate form in that the ascogonia are produced in a gametophytic primordium at the end of a rhizomorph. It would appear—so perfect is selection—that the middle course is the one most frequently pursued, but the number of species which have been examined does not allow of definite statement.

Angiocarpic and gymnocarpic development have been strongly contrasted, but Dodge (12) has shown that the distinction cannot be of great moment in classification because both kinds may occur in a natural genus, *e.g. Ascobolus*. Indeed, the middle course shows that the distinction is one of degree and may depend on the extent of apical growth of the investing hyphae which may in turn be connected with the time of emergence of the ascogenous hyphae. Investigation of other species will doubtless solve the problem.

Stipitate apothecia.

The structure of part of a simple helvelloid ascocarp is shown diagrammatically in Text-fig. 4 (*g*). The apothecial part is built on the same plan as the sessile form. The medulla is composed of very closely interwoven hyphae, 3–5 μ wide, the origin of which can be traced from the proximal parts of the hyphae in the marginal growing-point. The cortical hyphae keep their palisade arrangement and form clavate rows of inflated cells, 10–20 μ wide, on the underside of the apothecium. Both medulla and cortex occur in the stem where they have the same character and are the only tissues; the two layers are continuous through the ascocarp. From Lagarde's account of the ascocarps of *Morchella, Helvella, Acetabula*, etc., it is plain that all stipitate apothecia of Operculeae are so constructed. In those with a lacunose or hollow stem the cortex is continuous over the whole surface and it extends also over the inside of the fertile region of morchelloid forms.

The development of the sterile system of hyphae in a stipitate apothecium has not yet been investigated in detail, but McCubbin (21) has described the general procedure in *Helvella elastica*. Text-fig. 4 (*a–e*), are successive stages in the development of the primordium and (*f*) represents a mature fruit-body drawn to the same scale. The ascocarp is evidently initiated by a shaft of hyphae growing away from the substratum. The shaft is comparable with that which invests the ascogonium in sessile apothecia but differs in the extent of upgrowth; it is of longer duration, so that a stem-region is laid down. On cessation of upgrowth the distal parts of the hyphae are transformed into paraphyses and, owing to the development of a marginal growing-point, the upper part of the primordium broadens into



Text-fig. 4. Diagram of the structure and development of the ascocarp of *Helvella elastica*: *a–f* × 2: *a–e* after McCubbin: *f* mature ascocarp.

a shallow cup. But at a very early stage intercalary growth of the hymenium becomes excessive; the sides of the apothecium are reflexed and the primordium acquires the helvelloid shape. McCubbin states that the ascogenous hyphae arise from ordinary

sub-hymenial cells about the time when the apex of the primordium begins to expand, stage (*c*). However, Duff(14) considers certain "storage cells," which McCubbin describes in the sub-hymenium, to be ascogonia and believes that the apothecium is compound, like some of the Geoglossaceae. But the point has no bearing on the present purpose.

The noteworthy fact is the very early stage and hence the very small size of the primordium in which the parts of the mature ascocarp are defined. The hymenium begins to develop when the primordium is only 1·25 mm. high, stage (*c*), in which case the stem-region must already be formed, though it seems out of all proportion to the mature stem. As a matter of fact, this mode of development is characteristic of a great variety of fruit-bodies in both Ascomycetes and Basidiomycetes. It is the principle of the "toadstool-habit" in which the fruit-body rapidly attains full size and activity by the enlargement of the cells in certain motor-tissues laid down in relatively minute primordia. Development of such fruit-bodies takes place in two stages. There is firstly the period of tissue-formation when the hyphae grow and branch in a primordium, and secondly the period of expansion when the cells of the motor-tissues enlarge; expansion is usually accompanied with intercalary growth of the hymenium. Two-stage, or *indirect*, development has probably evolved by some alteration in the time-factor from the *direct* method in which cell-enlargement follows more or less closely on cell-formation in the growing-point. The direct method is illustrated by the basidiocarps of Clavariaceae and Polyporaceae in which apical growth continues until they have almost reached full length, in contrast to those of *Amanita*, *Coprinus* or Phalloidaceae. The direct method occurs in Discomycetes in the extension of the apothecium by marginal growth, but, apparently, the development of the stem is invariably indirect, unless it be in stipitate Ciboriaceae. But the point will be considered in connection with the Geoglossaceae.

In *H. elastica* the stem must elongate about fifty times its initial length during elevation of the apothecium, for it is about 1 mm. long when the hymenium begins to form and 4–6 cm. at maturity. The motor-tissue, as must be the case in all helvelloid and morchelloid ascocarps, for they have the same structure, is the cortex and not the medulla, as might be expected. Elongation is due in part to the lateral distension of the cells of the cortical hyphae, which are more or less perpendicular to the surface of the stem, but it must be due in part also to intercalary growth of the cortex after the stem-region has been laid down, because the increase in width of the cells, from 3–5 μ to 10–20 μ, does not account alone for the increase in length of the stem.

It should be mentioned that McCubbin describes a "veil" which encloses the primordium of *H. elastica* and is ruptured at an early stage, but it is questioned by Fitzpatrick (16) and it seems advisable to leave the matter for reinvestigation.

Forms of ascocarp.

All monaxial ascocarps of Discomycetes can be classed either as stipitate or as sessile apothecia. In each class there are several more or less distinct forms, and, having described the main processes in the development of the ascocarp, the nature of these forms can now be explained.

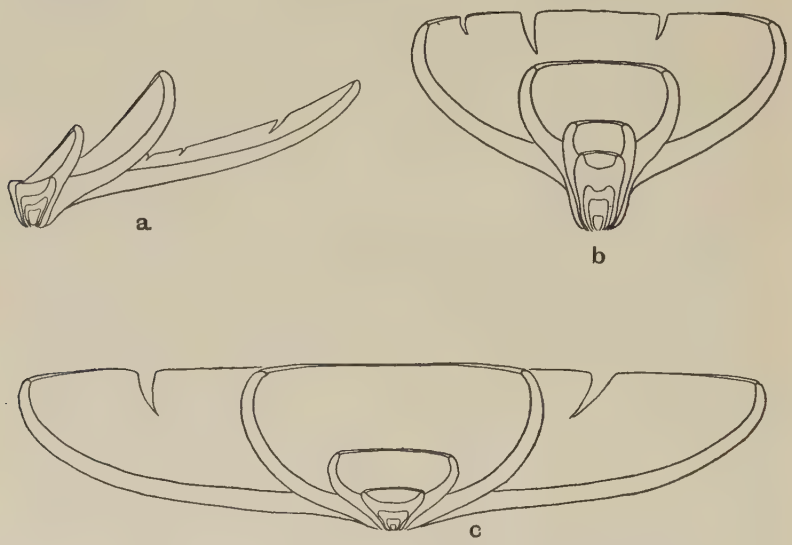
The forms of sessile apothecium, in roughly descending order of complexity, are the cupular, the lenticular, the "turbinulate," the perithecioid, the "cleistocarpic" and the immarginate; they constitute a developmental series.

The distinction between cupular and lenticular forms is best explained by describing the transformation of a large apothecium during the secondary period of development. Successive stages in the development of the apothecium of *Peziza aurantia* are drawn in Text-fig. 5 (*c*), the youngest of which corresponds roughly with (*h*), Text-fig. 2, or (*f*), Text-fig. 3. The hymenium is at first plane but becomes more and more concave until it begins to flatten into a disc again towards maturity: the apothecium enlarges by marginal growth and by intercalary growth of the hymenium. The direction of the hyphae in the marginal growing-point is at first upward, or away from the substratum, but the margin is gradually incurved and the direction of the hyphae is altered by nearly 90° before reversal begins. The transformation is caused by the antagonistic tissue-pressures of the cortex and hymenium. The effect of the cortical pressure, due to the branching and inflation of the cortical cells, is to force the margin inward and that of the hymenium, due initially to the branching of the paraphyses and ascogenous hyphae, is to force the margin outward. If the two developed equally, the apothecium would be discoid throughout, but the cortical pressure at first exceeds that of the hymenium and only later, when the hymenial pressure is augmented by the intercalation of asci, can it overcome the resistance of the cortex and force the sides of the apothecium apart. The curvature of the sides indicates the balance between the two forces along that radius and the rate of flattening, which proceeds centrifugally, should indicate the rate of maturing of the hymenium, or the time required by the apothecium to come into action after taking up position: data on such points would be interesting.

The state of balanced tissue-pressures is revealed in the mature apothecium by a sudden drop in hymenial pressure through the simultaneous discharge of many asci; the sides of

the apothecium jump inward as the hiss of discharge is heard and the spore-cloud appears immediately after over the hymenium. This exceedingly characteristic demonstration of the apothecial mechanism was first recorded by Haller in a letter to Linnaeus about 1750 (23).

If marginal growth continues for some time, the result is the large, relatively thin, cupular form of apothecium, 2–15 cm. wide, *e.g.* the last three stages in series (*c*), Text-fig. 5, which may be cupular, discoid or concave at maturity, according to the balance of tissue-pressures. Other things being equal, the



Text-fig. 5. Stages in the development of the ascocarp of *Peziza aurantia*, × 2: (*a*) of the auriculate form, (*b*) of the substipitate form, (*c*) of the sessile form.

convexity of the mature apothecium is a measure of its inefficiency, expressed as the ratio of sterile to sporogenous tissue. *Galactinia* and *Geopyxis* provide examples of persistently cupular forms, while *Discina* and *Rhizina* present the other extreme.

On the other hand, early cessation of marginal growth produces the small, relatively thick, lenticular form, 0·05–2 cm. wide, *e.g.* the first four stages of series (*c*). *Humaria* is the best example of a genus with lenticular apothecia.

A peculiar variety of the cupular form, in a sense intermediate between cupular and lenticular, is the auriculate, or spathulate. It is characterised by the cessation of marginal growth on one side of the apothecium at an early stage, so that further enlargement is more or less unilateral. In Text-fig. 5 a series of stages

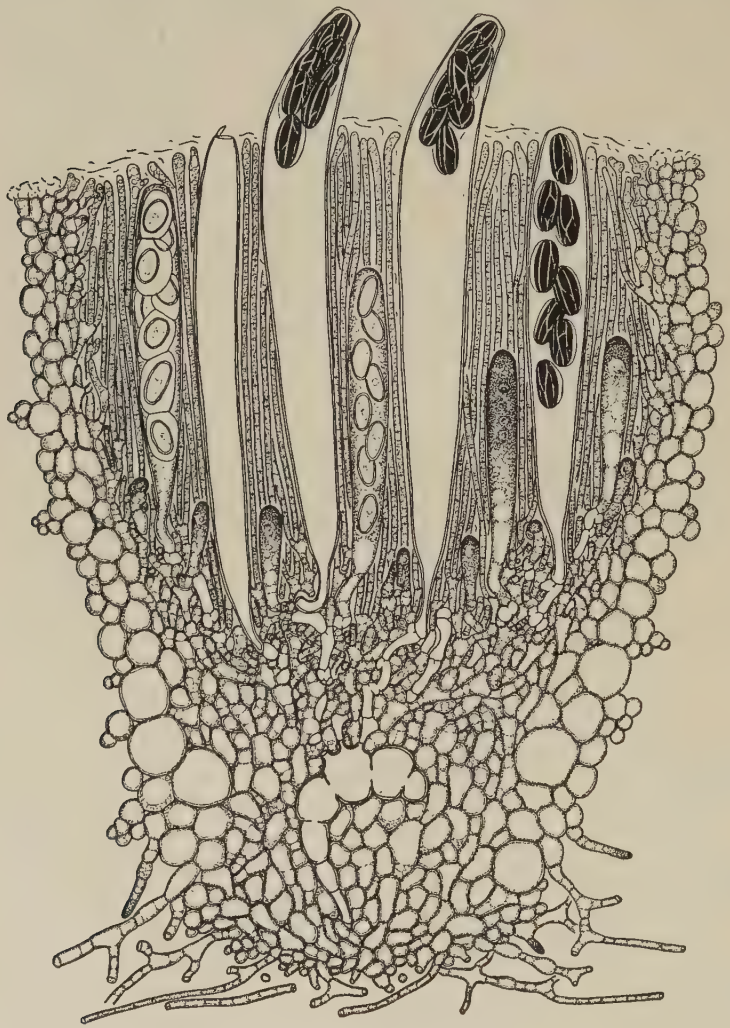
in the development of such a variety of *P. aurantia* is drawn, the sections being through the median plane; one-half of the apothecium is lenticular and the other is cupular. The auriculate variety shows perhaps even better than the hemispherical cups of cupular forms the precision with which development may be controlled, for in the beautifully symmetrical apothecia of *Otidea leporina*, and other species, marginal growth must decline regularly from one side to the other across the disc.

If an angiocarpic apothecium does not enter upon a secondary period of development, but remains structurally comparable with stage (*g*), Text-fig. 2, a very distinct form is produced for which the writer suggests the name *turbinulate*, in pursuance of Boudier's method of description. Turbinulate apothecia are characteristic of the angiocarpic Ascobolaceae already mentioned; a section of that of *A. stercorarius* is drawn in Text-fig. 6, though it is from a very diminutive specimen. They are small forms, 0·2–8 mm. wide, in which the part of the primary sheath overlying the hymenium is ruptured and further enlargement of the disc is due entirely to intercalary growth of the hymenium, mainly of ascogenous hyphae. They have hitherto been classed with small lenticular forms, which they may resemble in shape, but they have no marginal growth. However, there may be an abortive sprouting from the cortical cells at the margin and the cells of the outermost paraphyses may enlarge somewhat and suggest a disinclination to become cortical hyphae, *e.g. A. stercorarius*.

The perithecioid apothecium, 0·2–0·5 mm. wide, which the writer has described for *Neotiella Crozalsiana* (7), is similar to the turbinulate, but there is little intercalary growth of the hymenium; the sprouting of the cortical cells is more regular and forms a definite margin encircling a pore through which the asci dehisce.

In the same way the apothecia of *Thelebolus* and certain species of *Rhyparobius* can be explained. They may be called *cleistocarpic*—to coin another incongruity—for they have no more of a hymenium than the cleistocarps of Erysiphaceae and the condition of *Thelebolus* is almost exactly paralleled in *Sphaerotheca*. The apothecia of *Thelebolus* 0·1–0·3 mm. wide, are angiocarpic. The archicarp, according to Ramlow, consists of half a dozen cells, a central one of which is the ascogonium. Sterile hyphae envelop the archicarp in a primary sheath and the ascogonium develops directly into the one huge ascus in a mucilage cavity formed by the dissolution of the surrounding hyphae. The ascus eventually ruptures the sheath and dehisces. There are neither ascogenous hyphae nor paraphyses and the mature state corresponds to stage (*c*), Text-fig. 2. In those

species of *Rhyparobius* with only two to four polysporous asci per apothecium development is similar, according to Dangeard,



Text-fig. 6. Median section of a diminutive apothecium of *Ascobolus stercorarius*. × 250.

but a few paraphyses may grow into the mucilage cavity and the asci are produced singly on short ascogenous hyphae; the apothecia correspond roughly with stage (*d*), Text-fig. 2. In others the paraphyses are more numerous and the ascogenous

hyphae produce more than one ascus, and the best developed apothecia in the genus are turbinulate with a normal hymenium, *e.g.* the species examined by Barker.

The immarginate form, also of small size, 0·2–2 mm. wide, is characterised by the absence of a cortical margin to the hymenium. It occurs in the genera *Pyronema, Ascodesmis* and *Zukalina,* and is evidently a gymnocarpic apothecium without a secondary period of development. The structure of the mature apothecium of *P. confluens,* from Claussen's account, corresponds to a stage intermediate between (*c*) and (*d*), Text-fig. 3. The upgrowth of the sterile hyphae is soon arrested, their distal parts are transformed into paraphyses and the cells at the base of the apothecium enlarge to form a pseudoparenchyma. *Zukalina* is probably the same. But the organisation of the sterile tissue in *Ascodesmis nigricans,* from Claussen's account, is the simplest that has yet been described in Discomycetes. The apothecia mature in a state corresponding to stage (*b*), Text-fig. 3, or Text-fig. 2, if indeed there is any distinction at so early a period of development. The few sterile hyphae which envelop the ascogonia are transformed directly into paraphyses—about fifty per apothecium—and the ascogenous hyphae which are only a few cells long, produce a single ascus each. Dangeard (10), however, describes a pseudoparenchymatous base to the apothecium like that of *Pyronema,* and probably the extent of development varies just as in *Rhyparobius.*

The chief forms of stipitate apothecium in Operculeae are the cupular, the helvelloid and the morchelloid. Of the first it need only be said that it differs from the corresponding sessile form in the possession of a stalk, or a longer period of upgrowth, *e.g. Sarcoscypha, Acetabula.* The helvelloid form is characterised by the large amount of intercalary hymenial growth which begins so early in development that the apothecium never passes through a cupular stage. The sides of the apothecium are reflexed against the stem, to which they may be secondarily conjoint, and the lobings of the disc are caused by irregularities in growth: there are commonly two opposed regions of slight growth which gives the saddle-shape to many species of *Helvella.* The convolute bullate apothecia of *Gyromitra* and *Physomitra* are merely examples of excessive intercalary growth coupled with little or no marginal growth, and such an arrangement seems to provide an explanation of the morchelloid form, but the point will be discussed after the examination of the Geoglossaceae.

A complementary series can be recognised in Inoperculeae, though in miniature, on an apothecial scale of 0·01–2 cm. diameter, for they never reach the large size of operculate fruit-bodies.

There are elaborate stipitate apothecia in the Clavuleae, stipitate cupular forms in the Ciboriaceae, sessile cupular and lenticular forms in the Helotiaceae, Spisseae, etc., turbinulate forms in *Heterosphaeria* and probably most Patellariaceae, an immarginate form in *Ascocorticium*, and a medley of ill-defined apothecia in the Stictidaceae and Phacidiaceae which cannot be reviewed for lack of adequate description. Some develop on gymnocarpic lines, as *Geoglossum* and *Helotium*, others on angiocarpic lines, as *Microglossum*, *Bulgaria* and *Trichopeziza*, *Tapesia* and *Arachnopeziza*, according to Bayliss Elliott (2), and probably all of the "cartilaginous" group. What evolutionary principles apply in general to the one section of Discomycetes will clearly apply in general to the other, and attention will be confined, as hitherto, mainly to the better known Operculeae.

It need scarcely be mentioned that all transitions between the different forms of ascocarp occur, and not infrequently, so that only the more pronounced configurations can be named. In Text-fig. 5 (*b*) successive stages in the development of the substipitate form of *P. aurantia* are drawn; had the period of upgrowth been longer a stipitate apothecium, comparable in respect of gametophytic tissue with that of *Helvella*, would have resulted. Yet in Boudier's system of Discomycetes, which admittedly is the one attempt at a natural classification, the majority of families are distinguished by the form of the ascocarp. The effect of such a system of families, in the writer's opinion, is to classify the ascocarps of Discomycetes in a direction which cuts straight across their path of evolution. Certain series of Operculeae, which appear to be natural, will therefore be considered here.

Series of Operculeae.

Reference has already been made (7) to a most distinct humariaceous series characterised by the presence of carotin in the paraphyses. The series contains stipitate apothecia, *e.g. Sarcoscypha*, sessile cupular apothecia, *e.g. Peziza*, lenticular apothecia, *e.g. Humaria*, and the one species with perithecioid apothecia, *e.g. N. Crozalsiana*: turbinulate and immarginate apothecia apparently do not occur, though the former perhaps in *Lasiobolus*.

A second series of genera, *Helvella*, *Leptopodia*, *Cyathipodia*, *Macropodia* and *Acetabula*, can be distinguished by the grey colour of the hymenium, which may be due to a special pigment, the oval uniguttate spores, the gutta apparently derived from a single oleaginous centre, and the construction of the sterile tissue, according to Lagarde. It comprises helvelloid, and stipitate and sessile cupular, forms.

A third series, the Aleurieae of Boudier, distinguished by the presence of an amyloid substance in the ascus-wall, the purple or brown pigment in the paraphyses and the markedly pseudo-parenchymatous excipulum, comprises substipitate and sessile, cupular and lenticular forms. The series is interesting because the transitions occur separately in *Galactinia* and *Aleuria*, if not several times in each, and sessile cupular and lenticular forms occur in both *Plicaria* and *Pachyella*.

Another series, ranging from sessile cupular to lenticular forms, may possibly be distinguished by the pilose apothecium and by the absence of pigment in the paraphyses. It would include *Sepultaria, Lachnea, Trichophaea* and *Tricharia*, but they may only be unpigmented forms of the humariaceous series, cf. *Leucoscypha, Neotiella*.

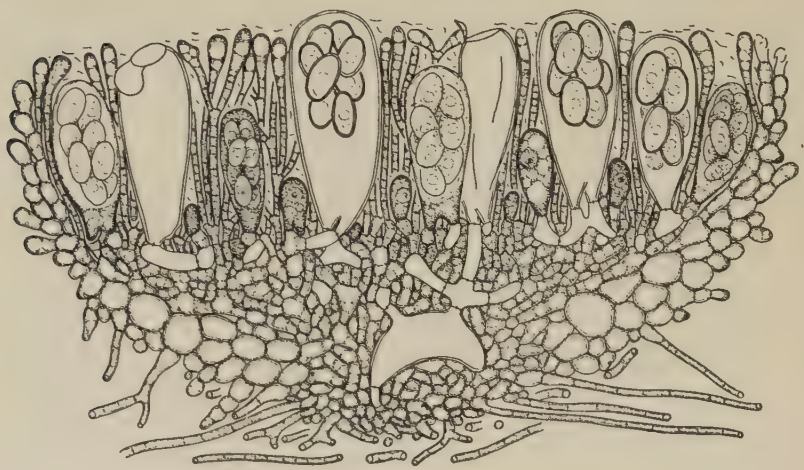
And finally the large composite genus, *Ascophanus*, may be mentioned. Some species are turbinulate, as *A. carneus*, and connect with *Rhyparobius* and thus with the cleistocarpic form in *Thelebolus*; the archicarp is similar in all three cases. *Rhyparobius* is separated from *Ascophanus* mainly by the squat form of the ascus and the multiplication of the octad, giving polysporous asci, but the distinction is largely one of opinion, for there is *A. sexdecimsporus*, while species of *Rhyparobius* may have only thirty-two spores per ascus, and *R. ascophanoides* Sacc. is synonymous with *A. rhyparobioides* Heim., according to Massee (20). There may also be a gymnocarpic series, for Dangeard finds that *A. ochraceus* has immarginate apothecia like *Pyronema*; they develop in the same way from a rosette of ascogonia, and in both genera the spores are colourless and eguttate. And yet other species are minute lenticular forms on hemiangiocarpic lines, of doubtful affinity, for example *A. granuliformis*, Text-fig. 7, which has been drawn for comparison with the minute turbinulate apothecium of *Ascobolus*. And if, moreover, to these illustrations be added Claussen's of *Pyronema*, an example is afforded from each mode of development of a sessile apothecium which can be considered to have matured at a correspondingly early stage.

Summary.

The chief processes in the development of the stipitate apothecium are upgrowth from the substratum, which defines the axis or stem, and marginal and intercalary hymenial growth which define the apothecium. The development of the stem is *indirect* in that cell-enlargement follows as a separate stage on cell formation. The tissue-pressures of cortex and hymenium are antagonistic and give rigidity to the apothecium. Likewise, in the sessile apothecium can be distinguished a primary period

of upgrowth, from initiation of the apothecium to the formation of the hymenium, and a secondary period of marginal and intercalary growth.

Helvelloid, cupular, lenticular, perithecioid and immarginate forms of ascocarp are interpreted developmentally, and two additional forms, described as *turbinulate* and *cleistocarpic*: both are angiocarpic sessile apothecia without a secondary period of development, the turbinulate with, and the cleistocarpic without, a definite hymenium. These forms are shown to constitute a developmental series.



Text-fig. 7. Median section of an apothecium of *Ascophanus granuliformis*. × 500.

Certain series of Operculeae which are considered to be natural are briefly described.

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A NEW SPECIES OF OIDIUM.

By A. Chaston Chapman, F.R.S.

(With Plate VII.)

ABOUT two years ago I was consulted in regard to a growth occurring in the sewer connecting a factory with the main sewer of a town. This growth occurred so rapidly and so freely that, after having been cleaned, the sewer in question became in a very short time almost blocked. This sewer was used for the purpose of conveying the factory effluent to the town sewer and was joined at a certain point by a side drain carrying a very small quantity of domestic sewage.

The growth above referred to always commenced just below the point at which the domestic sewage entered, and from this point onwards developed into a hard, gelatinous or tough leathery mass which ultimately blocked the sewer, and caused both the Firm and the town authorities a considerable amount of trouble.

The growth—for such it proved to be—consisted of a dark brown gelatinous mass, having the toughness of soft leather.

A preliminary examination showed that it consisted of a mass of mycelium, together, of course, with numerous bacteria and other organisms. No spores were apparent. It was obvious that the mould was the predominant organism, and that it was mainly, if not entirely, responsible for the trouble. The factory effluent was faintly acid in reaction, and contained about 1 grm. per 100 c.c. of total dissolved matter, consisting mainly of sodium acetate and sodium sulphate. There was no carbohydrate matter, nor was there any nitrogen.

The mould was, in the first instance, separated from the other organisms by cultivation in special media, followed by plating out in wort-agar. In this way pure cultures were obtained. It formed in the course of a few hours on the surface of nutrient media, a thick, white felty growth, the mycelial tubes being very clearly septated and branching. The spores were thick-walled, large and usually oblong. The two outstanding features of this mould of significance from the industrial point of view are its rapid growth under suitable conditions, and its property of forming very tough films or pellicles on the surface on which it is developing.

Experiments showed that the mould grew very slowly indeed in the factory effluent alone, but that when a little nitrogen was added in the form of sterilised domestic sewage the growth became very rapid. This obviously explains the fact that the mould did not develop in the factory sewer until the point was reached at which the domestic sewage entered, the necessary carbon being, of course, supplied by the sodium acetate.

From a preliminary examination it was clear that this mould was an *Oidium,* and a more detailed study showed that it differed in certain respects from any of the known species, especially in the tough leathery form assumed by the mycelium, and the thick walls and large size of the spores.

The following are the results of culture experiments made with this organism:

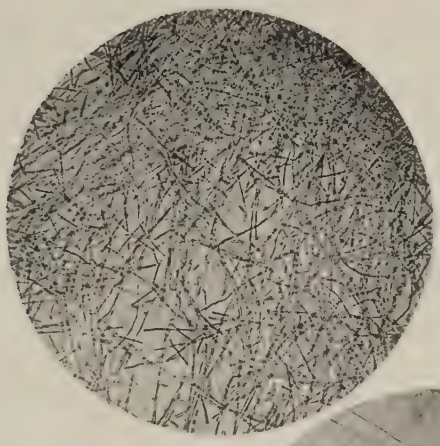
Malt wort. On this the mould grew rapidly, producing a white film which soon became tough and leathery. There was no production of gas, and little, if any, acid was formed even at the end of ten days.

Wort agar slopes. The mould grew freely, forming a dry white felty growth.

Fermented malt wort. No growth occurred even after fourteen days, nor was there any production of acidity.

Sterilised milk. A white felty growth formed, and the acidity, which was 0·13 per cent. at the commencement of the experiment, increased to 0·5 per cent. at the end of six days.

Glucose broth. There was a thick white felty growth, but there



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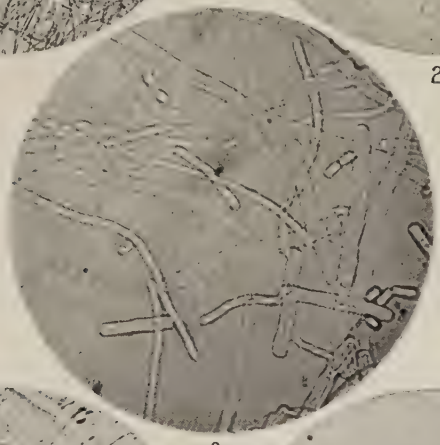

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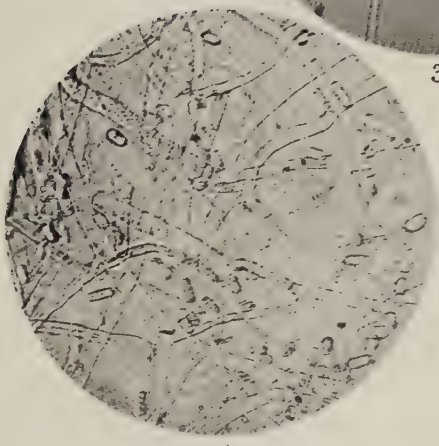

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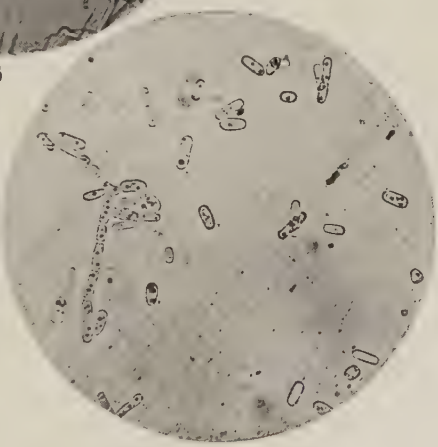

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was no gas production, nor was there any formation of acidity. The growth was not as luxuriant as on the malt wort.

Lactose broth. The results were very similar to those obtained with glucose broth.

Raulin's solution. There was fairly rapid growth.

Nutrient gelatine. There was slow growth, but no liquefaction even at the end of ten days.

The organism is strictly aerobic, no growth having been observed in any of the media under anaerobic conditions.

The spores averaged 12–14 μ in length, some, however, attaining a length of 20 μ. In width they varied from about 5–10 μ.

A reference to the literature of the subject showed that this organism most closely resembled *Oidium matalense* isolated by Castellani in 1915. I therefore sent some cultures to Sir Aldo Castellani who was good enough to examine them, and who confirmed me in my view, saying that, although resembling *matalense*, it was "a different species, or at least a different variety." He added that he proposed to refer to it in the new edition of Castellani and Chalmer's *Manual of Tropical Medicine.*

Whether this species is parasitic on man, and, if so, whether it possesses any pathogenic properties, I do not know, but, as will have been gathered, it may have at times a very important industrial significance.

I desire to offer my best thanks to my Biological Assistant, Mr C. W. McHugo, F.I.C., for his valuable assistance in connection with this work, and to Sir Aldo Castellani for having very kindly examined cultures for me.

DESCRIPTION OF PLATE VII.

Fig. 1. Young vigorous growth—low magnification.
Fig. 2. Twenty-four hours' growth on malt wort.
Fig. 3. Forty-eight hours' growth on malt wort, showing thickening of the cell walls and the formation of the thick wall spores.
Fig. 4. Five days' growth on malt wort.
Fig. 5. Growth at the end of fourteen days, showing spores only.

SOME FUNGUS FORAYS IN AMERICA.

By Carleton Rea, B.C.L., M.A. and J. Ramsbottom, O.B.E., M.A.

At the International Congress of Plant Sciences (Fourth International Botanical Congress), held at Ithaca, N.Y., U.S.A. from the 16th to the 23rd of August, 1926, three fungus forays were arranged for the benefit of the mycologists attending the conference. These included visits to Enfield Glen, Coy Glen, and

the McLean Bogs at the Lloyd Wild Life Preserve; the last place is interesting to mycologists in particular because it was the gift to Cornell University of the well-known American mycologist C. G. Lloyd. Subsequently another foray was organised by Professors H. H. Whetzel and H. M. Fitzpatrick, which occupied from the 11th to the 16th of September, during which the woods adjoining the Cornell University Campus, Labrador Lake, Tanghannock Falls and Gorge, and Six-mile Creek were explored and Coy and Enfield Glens again visited. Fungi abounded on both occasions and many very interesting species were collected. In the lists are included fungi observed by one of us (C. R.) in the woods near Chicago, and in the Yellowstone and Rocky Mountain National Parks and by the other in woods near Cincinnati, Washington, and in the neighbourhood of New York City. We think it will be of interest to mycologists in this country to see a list of the larger fungi collected during our visit. Several interesting rusts and other micro-fungi were observed, but these are not enumerated. We cannot, however, omit to mention the effects of *Endothia parasitica* (Murr.) And. and And., the chestnut blight, which are startlingly obvious in the eastern states where the blasted trees remind one of the damage caused by modern warfare; dead, isolated trees dotting the landscape in some regions like they do in eastern France.

When first visiting Enfield Glen the impression we had was that though there was a strange familiarity about the fungi there was a different sort of balance, or, as was said, one had a feeling of having returned to the study of field mycology after a lapse of years. The majority of species observed were those we meet with in this country and were typical in every way. Occasionally, however, there were differences which are difficult to explain without a series of illustrations; the species was obviously the European species but the range of variation was different, the commonest American form not being the one we are accustomed to. As an example we may mention *Amanita muscaria*. Nowhere in the American woods did we see this species with a brilliant scarlet cap, such as makes it the best known toadstool in England, but always of an orange colour more like what we regard as typical for the variety *formosa*. This is to be noted in most illustrations of the American form. On the other hand, what is commonly figured and described as *Amanita phalloides* in American works is not that species but one which has been named *A. brunnescens* by Atkinson. Typical *A. phalloides* was seen by us and also the variety *verna* but *A. brunnescens* was the common species. Three other endemic species of *Amanita* were also seen. *A. bisporiger* Atk., much like *A. verna* but with bispored basidia; *A. Frostiana* Peck, in

abundance, and *A. flavoconia* Atk., rarely, the last two looking somewhat like small specimens of *A. muscaria.*

As was to be expected, the relative numbers of species, *i.e.* comparative rarity and abundance, was different from that in England; thus *Omphalia campanella* (Batsch) Fr., which is only occasional in England, occurred in great quantities.

Two genera new to us were *Tremellodendron,* with its two species, *T. candidum* (Schw.) Atk. and *T. pallidum* (Schw.) Burt; and *Physalacria. Tremellodendron* has the appearance of a dendroid *Thelephora* but has globose, cruciately divided basidia.

Physalacria inflata (Schw.) Peck, forms clusters of small white bladder-like heads on slender stalks; it is a much named fungus, for which Krieger has recently (1923) proposed the new genus *Eoagaricus,* overlooking the fact that this species was the one on which Peck based his genus.

The genus *Boletinus* was represented by two abundant species, *B. pictus* Peck and *B. porosus* (Berk.) Fr. while there were several interesting endemic species of *Boletus,* those with a raised reticulation on the stipe being of singular beauty. Other striking endemic species seen in abundance were the small brightly coloured *Cantharellus cinnabarinus* Schw. and the larger trumpet-shaped *C. floccosus* Schw.

Other species worthy of special mention are *Lactarius indigo* Schw. which well deserves its trivial name, every part except the spores being indigo blue; *Mycena Leaiana* Berk., a beautiful orange-red species occurring in clusters, and *Psaliota placomyces* Peck, with a white cap and brown pointed scales more crowded in the centre. The remaining common endemic species we collected were *Boletus americanus* Peck, *B. chromapes* Frost, *B. griseus* Frost, *Clitopilus abortivus* B. and Curt., *Collybia strictipes* Peck, *Hygrophorus miniatus* Fr. var. *cantharellus* Schw., *H. Peckii* Atk., *Hypomyces lactifluorum* (Schw.) Tul., *Lactarius atroviridis* Peck, *L. deceptivus* Peck, *L. hygrophoroides* B. and Curt., *Marasmius nigripes* Peck, *M. siccus* Schw., *Spathularia velutipes* Cke. and Farl., *Stereum fasciatum* (Schw.) Fr., *S. rameale* Schw.

The more uncommon species observed were *Boletus auripes* Peck, *B. Frostii* Russ., *B. nigrellus* Peck, *B. retipes* B. and Curt., *B. Russellii* Frost, *Collybia familia* Peck, *Cortinarius* (*Phleg.*) *corrugatus* Peck, *C.* (*Myx.*) *cylindripes* Kauff., *C.* (*Ino.*) *flavifolius* Peck, *Crinipellis zonatus* (Peck) v. Hoehn., *Entoloma cuspidatum* Peck, *Hydnum pulcherrimum* Peck, *Lactarius griseus* Peck, *Lepiota acerina* Peck, *Pholiota rugosa* Peck, *Polyporus Berkeleyi* Fr., *P. radicatus* Schw., *Psilocybe larga* Kauff., *Stereum diaphanum* (Schw.) Cke., and *Tremella reticulata* (Berk.) Farl.

It was an especial pleasure to take part in fungus forays at

places where the late Professor G. F. Atkinson of Cornell had so often collected and to do so in company with many of his old students. One of us paid a visit to the late Dr C. G. Lloyd and did a little collecting in his company, but he was then nearly blind.

We are greatly indebted to many American mycologists for their kind assistance in the naming of specimens, particularly Professors E. A. Burt, H. M. Fitzpatrick, C. H. Kauffman, L. O. Overholts, H. H. Whetzel and Drs B. O. Dodge and C. L. Shear. To many other mycologists we would also express our thanks for making our visit both pleasant and profitable.

C. =Coy Glen; *Chi.* =woods at Tremont, near Chicago; *Cin.* =woods at Crittenden, near Cincinnati; *E.* =Enfield Glen; *I.* =Campus and woods near Ithaca; *L.* =Labrador Lake; *M.* =McLean Bogs at the Wild Life Preserve; *N.Y.* =New York; *S.* =Six-mile Creek; *T.* =Tanghannock Falls; *W.* =Washington; *Y.* =Yellowstone National Park.

GASTEROMYCETAE.

Rhizopogon rubescens Tul., *C.*
Lycoperdon candidum Pers., *E.*, craniiforme Schw., *Y.*, perlatum Pers., *C.*, *Cin.*, pyriforme (Schaeff.) Pers., *C.*, *W.*
Bovista pila B. & Curt., *C.*, plumbea Fr., *I.*
Geaster rufescens Pers., var. minor Pers., *L.*, saccatus Fr., *Chi.*, *L.*, *T.*, triplex Jungh., *L.*
Crucibulum vulgare Tul., *L.*, on horse-dung.
Cyathus striatus (Huds.) Pers., *N.Y.*
Scleroderma aurantium Pers., *C.*, cepa (Vaill.) Pers., *E.*, *S.*
Astraeus hygrometricus (Pers.) Morg., *Y.*

HYMENOMYCETAE.

Pluteus cervinus (Schaeff.) Fr., *I.*, *L.*, *Cin.*, nanus (Pers.) Fr., *C.*
Lepiota acerina Peck, *L.*, acutesquamosa (Weinm.) Fr., *I.*, Friesii (Lasch) Fr., *L.*, granulosa (Batsch) Fr., *E.*, haematosperma (Bull.) Boud., *L.*, seminuda Fr., *C.*
Psaliota campestris (Linn.) Fr., *Cin.*, placomyces Peck, *E.*, sylvicola (Vitt.) Fr., *C.*
Amanitopsis fulva (Schaeff.) W. G. Sm., *L.*, strangulata (Fr.) Roze, *E.*, vaginata (Bull.) Roze, *C.*, *Chi.*, *Cin.*
Volvaria speciosa Fr., *L.*
Amanita bisporiger Atk., *C.*, brunnescens Atk., *C.*, *E.*, flavoconia Atk., *C.*, Frostiana Peck, *E.*, mappa (Batsch) Fr., *E.*, muscaria Fr., *C.*, *Y.*, phalloides (Vaill.) Fr., *E.* and var. verna (Bull.) Fr., *C.*, *S.*, porphyria (A. & S.) Fr., *C.*, *E.*, *S.*, recutita Fr., *E.*, rubescens (Pers.) Fr., *C.*, *E.*, *L.*, verna (Lam.) Fr., *C.*, *S.*
Armillaria mellea (Vahl) Fr., *C.*, *E.*, *L.*, *Cin.*, *N.Y.*
Rozites caperatus (Pers.) Karst., *E.*
Pholiota marginata (Batsch) Fr., *E.*, *L.*, mutabilis (Schaeff.) Fr., *C.*, *L.*, rugosa Peck, *I.*, unicolor (Fl. Dan.) Fr., *C.*, *L.*
Stropharia aeruginosa (Curt.) Fr., *C.*, *E.*, *L.*, melasperma (Bull.) Quél., var. lutescens Boud., *I.*, semiglobata (Batsch) Fr., *I.*, *L.*
Cortinarius (Hydro.) acutus (Pers.) Fr., *L.*, (Phleg.) aleuriosmus Maire, *E.*, (Derm.) anomalus Fr., *C.*, (Hydro.) armeniacus (Schaeff.) Fr., *C.*, (Tela.) armillatus Fr., *C.*, (Ino.) bolaris (Pers.) Fr., *C.*, *E.*, (Tela.) bovinus Fr., *C.*, (Tela.) brunneus (Pers.) Fr., *C.*, *S.*, (Tela.) bulbosus (Sow.) Fr., *E.*, (Phleg.) caerulescens Fr., *E.*, (Phleg.) caesiocyaneus Britz., *C.*, *E.*, (Ino.) callisteus

Fr., *E.*, (Derm.) caninus Fr., *C.*, (Hydro.) castaneus (Bull.) Fr., *E.*, *I.*, *Y.*, (Dermo.) cinnabarinus Fr., *C.*, *E.*, (Phleg.) corrugatus Peck, *C.*, (Myx.) cylindripes Kauff., *C.*, (Tela.) evernius Fr., *L.*, (Ino.) flavifolius Peck, *E.*, (Hydro.) germanus Fr., *S.*, (Tela.) hemitrichus Fr., *C.*, *L.*, (Phleg.) infractus (Pers.) Fr., *E.*, (Tela.) impennis Fr., *S.*, (Hydro.) leucopus (Bull.) Fr., *E.*, (Dermo.) ochroleucus (Schaeff.) Fr., *E.*, *L.*, (Tela.) paleaceus (Weinm.) Fr., *E.*, *L.*, (Tela.) rigidus (Scop.) Fr., *L.*, (Hydro.) saturninus Fr., *C.*, (Dermo.) semisanguineus (Brig.) Maire, *E.*, (Hydro.) subferrugineus (Batsch) Fr., *E.*, (Dermo.) tabularis (Bull.) Fr., *C.*, (Phleg.) triumphans Fr., *S.*, (Phleg.) varius (Schaeff.) Fr., *C.*, (Dermo.) venetus Fr., *E.*

Inocybe fastigiata (Schaeff.) Fr., *C.*, flocculosa Berk., *I.*, geophila (Sow.) Fr., *E.*, relicina Fr., *S.*, rimosa (Bull.) Fr., *E.*, *L.*

Astrosporina asterospora (Quél.) Rea, *E.*, *L.*, sabuletorum (B. & Curt.) Rea, *T.*

Tricholoma acerbum (Bull.) Fr., *C.*, albobrunneum (Pers.) Fr., *C.*, gambosum Fr., *Y.*, lascivum Fr., *C.*, *S.*, personatum Fr., *N.Y.*, psammopum Kalchbr., *C.*, rutilans (Schaeff.) Fr., *W.*, variegatum (Scop.) Fr., *S.*

Entoloma clypeatum (Linn.), Fr., *C.*, cuspidatum Peck, *C.*, griseum Peck, *L.*, lividum (Bull.) Fr., *E.*, nidorosum Fr., *E.*, *L.*, rhodopolium Fr., *C.*, *E.*, sericeum (Bull.) Fr., *L.*, speculum Fr., *E.*

Hebeloma crustuliniforme (Bull.) Fr., var. minus Cke., *S.*, fastibile Fr., *L.*, glutinosum (Lindgr.) Fr., *E.*, mesophaeum Fr., *L.*

Hypholoma appendiculatum (Bull.) Fr., *C.*, capnoides Fr., *E.*, epixanthum Fr., *L.*, fasciculare (Huds.) Fr., *I.*, *L.*, hydrophilum (Bull.) Fr., *C.*, *L.*, incertum Peck, *C.*, *I.*, sublateritium (Schaeff.) Fr., *L.*, *N.Y.*, velutinum (Pers.) Fr., *L.*

Clitocybe anisearia Peck, *Chi.*, *I.*, candicans (Pers.) Fr., *I.*, claviceps (Pers.) Fr., *I.*, expallens (Pers.) Fr., *L.*, infundibuliformis (Schaeff.) Fr., *I.*, *Cin.*, odora (Bull.) Fr., *C.*, *L.*, *N.Y.*, olearia (DC.) Maire, *N.Y.*, pithyophila (Secr.) Fr., *E.*

Laccaria laccata (Scop.) B. & Br., *L.*, *W.*, and var. amethystina (Vaill.) B. & Br., *L.*, *W.*

Hygrophorus ceraceus (Wulf.) Fr., *L.*, *S.*, *I.*, chlorophanus Fr., *C.*, *I.*, coccineus (Schaeff.) Fr., *L.*, *I.*, conicus (Scop.) Fr., *Chi.*, *E.*, *L.*, *I.*, discoideus (Pers.) Fr., *C.*, eburneus (Bull.) Fr., *S.*, hypothejus Fr., *S.*, limacinus Fr., *C.*, miniatus Fr., *L.*, and var. cantharellus Schw., *C.*, *E.*, *S.*, Peckii Atk., *C.*, pratensis (Pers.) Fr., *L.*, psittacinus (Schaeff.) Fr., *C.*, *L.*, *I.*, Reai Maire, *E.*

Clitopilus abortivus B. & Curt., *C.*, prunulus (Scop.) Fr., *E.*, *L.*

Flammula gummosa (Lasch) Fr., *L.*, sapinea Fr., *I.*, spumosa Fr., *C.*, *I.*

Collybia acervata Fr., *L.*, cirrhata (Schum.) Fr., *E.*, distorta Fr., *E.*, *L.*, familia Peck, *I.*, floccipes Fr., *L.*, inolens Fr., *E.*, longipes (Bull.) Berk., *L.*, maculata (A. & S.) Fr., *L.*, *W.*, *Cin.*, platyphylla (Pers.) Fr., *L.*, *W.*, radicata (Relh.) Berk., *I.*, *L.*, *T.*, *W.*, strictipes Peck, *C.*, *E.*, *M.*, *S.*, tuberosa (Bull.) Fr., *L.*

Leptonia formosa Fr., *E.*, sericella (Fr.) Quél., *L.*

Naucoria escharoides Fr., *L.*, *T.*, siparia Fr., *L.*

Psilocybe larga Kauff., *L.*

Panaeolus campanulatus (Linn.) Fr., *C.*, *I.*, papilionaceus (Bull.) Fr., *L.*

Mycena alcalina Fr., *E.*, ammoniaca Fr., *I.*, *L.*, dissiliens Fr., *L.*, filopes (Bull.) Fr., *C.*, *L.*, galericulata (Scop.) Fr., *L.*, *Cin.*, haemotopus (Pers.) Fr., *C.*, *L.*, *M.*, *W.*, inclinata Fr., *E.*, Iris Berk., *C.*, *S.*, Leaiana Berk., *C.*, *E.*, *L.*, *M.*, *S.*, *Cin.*, *W.*, parabolica Fr., *L.*, *T.*, pelianthina Fr., *M.*, polygramma (Bull.) Fr., *C.*, *S.*, pura (Pers.) Fr., *L.*, *W.*, sanguinolenta (A. & S.) Fr., *C.*, *L.*, tenerrima Berk., *T.*, vulgaris (Pers.) Fr., *E.*, *S.*

Nolanea papillata Bres., *S.*, pascua (Pers.) Fr., *L.*, strigosissima Rea, *C.*, *L.*

Galera hypnorum (Schrank) Fr., *E.*, *S.*, tenera (Schaeff.) Fr., *I.*, *L.*

Psathyra fibrillosa (Pers.) Fr., *E.*, *L.*

Psathyrella atomata Fr., *I.*, crenata (Lasch) Fr., *I.*

Omphalia campanella (Batsch) Fr., *C.*, *E.*, *L.*, *M.*, *S.*, fibula (Bull.) Fr., *L.*

Tubaria pellucida (Bull.) Fr., *L.*

Pleurotus circinatus Fr., *L.*, septicus Fr., *L.*

Claudopus variabilis (Pers.) W. G. Sm., *L.*

Crepidotus mollis (Schaeff.) Fr., *L.*

Russula adusta (Pers.) Fr., *L.*, alutacea (Pers.) Fr., var. olivascens (Fr.) Rea., *E.*, atropurpurea (Krombh.) Maire, *C.*, *L.*, *Y.*, chloroides (Krombh.) Fr., *L.*, *W.*, *Y.*, cyanoxantha (Schaeff.) Fr., *I.*, *L.*, *Y.*, decolorans Fr., *Y.*, densifolia (Secr.) Gill., *C.*, *M.*, *Y.*, drimeia Cke., *C.*, emetica (Schaeff.) Fr., *C.*, *L.*, foetens (Pers.) Fr., *C.*, *Cin.*, fragilis (Pers.) Fr., *Chi.*, *L.*, incarnata Quél., *I.*, lepida Fr., *C.*, *E.*, *I.*, *S.*, lutea (Huds.) Fr., *L.*, mustelina Fr., *E.*, nigricans (Bull.) Fr., *E.*, ochroleuca (Pers.) Fr., *L.*, rubra (Krombh.) Bres., *C.*, veternosa Fr., *E.*, *I.*, virescens (Schaeff.) Fr., *L.*, xerampelina (Schaeff.) Fr., *C.*, *E.*, *I.*

Lactarius atroviridis Peck., *C.*, *S.*, camphoratus (Bull.) Fr., *C.*, *E.*, chrysorheus Fr., *L.*, colorascens Peck, *E.*, deceptivus Peck, *C.*, *E.*, *S.*, *W.*, deliciosus (Linn.) Fr., *I.*, glyciosmus Fr., *L.*, griseus Peck, *C.*, *L.*, hygrophoroides B. & Curt., *C.*, *E.*, *S.*, indigo Schw., *S.*, insulsus Fr., *L.*, lignyotus Fr., *L.*, *Cin.*, pallidus (Pers.) Fr., *C.*, *E.*, *L.*, piperatus (Scop.) Fr., *C.*, *L.*, *M.*, pubescens Fr., *L.*, pyrogalus (Bull.) Fr., *L.*, *S.*, serifluus (DC.) Fr., *C.*, *Chi.*, *E.*, *L.*, *S.*, subdulcis (Pers.) Fr., *C.*, *E.*, *I.*, *L.*, theiogalus (Fr.) Plowr., *C.*, torminosus (Schaeff.) Fr., *L.*, trivialis Fr., *I.*, *S.*, vellereus Fr., *I.*, *L.*, vietus Fr., *E.*, volemus Fr., *C.*, *L.*, *N.Y.*

Coprinus atramentarius (Bull.) Fr., *E.*, *L.*, *N.Y.*, cinereus (Schaeff.) Cke., *L.*, macrorhizus (Pers.) Rea, *S.*, micaceus (Bull.) Fr., *C.*, *L.*, *N.Y.*, radiatus (Bull.) Fr., *I.*

Marasmius cauticinalis (With.) Fr., *Y.*, cohaerens (A. & S.) Cke., *S.*, conigena (Pers.) Karst., *L.*, dryophilus (Bull.) Karst., *C.*, *Chi.*, *E.*, *L.*, *S.*, *Cin.*, erythropus (Pers.) Fr., *C.*, *L.*, foetidus (Sow.) Fr., *C.*, *E.*, *M.*, fuscopurpureus (Pers.) Fr., *C.*, hariolorum (DC.) Quél., *C.*, *E.*, *L.*, *N.Y.*, nigripes Peck, C.M., *Cin.*, oreades (Bolt.) Fr., *Y.*, peronatus (Bolt.) Fr., *C.*, *E.*, *L.*, *Cin.*, siccus Schw., *C.*, *E.*, *L.*, *M.*, *S.*, *Cin.*, *N.Y.*, varicosus Fr., *C.*

Androsaceus androsaceus (Linn.) Pat., *L.*, rotula (Scop.) Pat., *L.*

Crinipellis zonatus (Peck) v. Hoehn., *C.*, *L.*

Panus stipticus (Bull.) Fr., *N.Y.*

Lentinus cochleatus (Pers.) Fr., *I.*, lepideus Fr., *I.*, suffrutescens (Brot.) Fr., *C.*

Cantharellus cibarius Fr., *E.*, cinnabarinus Schw., *C.*, *M.*, floccosus Schw., *C.*, lutescens (Pers.) Fr., *L.*, umbonatus (Gmel.) Fr., *Chi.*

Craterellus cornucopoides (Linn.) Fr., *C.*

Physalacria inflata (Schw.) Peck, *E.*

Paxillus atrotomentosus (Batsch) Fr., *I.*, involutus (Batsch) Fr., *I.*, *L.*, panuoides Fr., *N.Y.*

Gyroporus castaneus (Bull.) Quél., *E.*, cyanescens (Bull.) Quél., *Chi.*

Tylopilus felleus (Bull.) Karst., *I.*, *W.*

Strobilomyces strobilaceus (Scop.) Berk., *Chi.*, *Cin.*

Boletinus pictus Peck, *E.*, *L.*, *Cin.*, porosus (Berk.) Fr., *C.*, *E.*, *L.*, *Cin.*

Boletus americanus Peck, *C.*, *E.*, *I.*, *W.*, auripes Peck, *Cin.*, bovinus (Linn.) Fr., *E.*, chromapes Frost, *C.*, chrysenteron (Bull.) Fr., *C.*, *E.*, *W.*, duriusculus Schulz., *C.*, *L.*, Frostii Russ., *W.*, granulatus (Linn.) Fr., *L.*, *W.*, *Y.*, griseus Frost, *C.*, *Chi.*, illudens Peck, *S.*, luteus (Linn.) Fr., *N.Y.*, nigrellus Peck, *Cin.*, reticulatus (Schaeff.) Boud., *C.*, *L.*, retipes B. & C., *W.*, Russellii Frost, *W.*, satanas Lenz., *C.*, scaber (Bull.) Fr., *C.*, *Cin.*, subtomentosus (Linn.) Fr., *L.*, versipellis Fr., *C.*, *S.*, viscidus (Linn.) Fr., *L.*

Polyporus adustus (Willd.) Fr., *I.*, *L.*, Berkeleyi Fr., *L.*, betulinus (Bull.) Fr., *L.*, brumalis (Pers.) Fr., *C.*, chioneus Fr. (=albellus Peck sec. Lloyd), *E.*, cinnamomeus (Jacq.) Sacc., *C.*, lacteus Fr. (=trabaeus Fr. sec. Lloyd), *C.*, intybaceus Fr., *C.*, perennis (Linn.) Fr., *S.*, radicatus Schw., *L.*, Schweinitzii Fr., *I.*, Spraguei Berk., *C.*, varius Fr., *L.*

Fomes fomentarius (Linn.) Fr., *L.*

Ganoderma applanatum (Pers.) Pat., *L.*, leucophaeum Mont., *L.*, *S.*, lucidum (Leyss.) Karst., *E.*, *L.*, Tsugae Murrill, *C.*, on *conifers*.

Polystictus hirsutus (Wulf.) Fr., *C.*, *L.*, pergamenus Fr., *L.*, on frondose wood, versicolor (Linn.) Fr., *C.*, *E.*, *L.*

Irpex cinnamomeus Schw., *E.*, tulipifera Schw., *C.*, *L.*

Lenzites saepiaria (Wulf.) Fr., *Y.*

Trametes rubescens (A. & S.) Fr., *C.*, *L.*

Daedalea confragosa (Bolt.) Fr., *C.*, *L.*, quercina (Linn.) Fr., *C.*, *L.*, unicolor (Bull.) Fr., *C.*, *L.*
Favolus europaeus Fr., *E.*
Merulius tremellosus (Schrad.) Fr., *L.*
Fistulina hepatica (Huds.) Fr., *E.*, *L.*, *W.*
Hydnum ferrugineum Fr., *C.*, fuligineoviolaceum Kalchbr., *Chi.*, imbricatum (Linn.) Fr., *C.*, nigrum Fr., *E.*, pulcherrimum B. & Curt., *E.*, repandum (Linn.) Fr., *C.*, and var. rufescens (Pers.) Fr., *L.*, scrobiculatum Fr., *C.*, zonatum (Batsch) Fr., *C.*
Mycoleptodon ochraceum (Pers.) Pat., *E.*, *L.*
Acia uda (Fr.) Bourd. & Galz., *E.*, *L.*
Phylacteria clavularis (Fr.) Big. & Guill., *L.*, terrestris (Ehr.) Big. & Guill., *L.*
Stereum diaphanum (Schw.) Cke., *E.*, fasciatum (Schw.) Fr., *C.*, *L.*, *S.*, hirsutum (Willd.) Fr., *C.*, *E.*, rameale (Schw.) Burt, *L.*, *S.*, rugosum (Pers.) Fr., *E.*, sericeum (Schw.) Morg., *I.*
Hymenochaete rubiginosa (Dicks.) Lév., *E.*, tabacina (Sow.) Lév., *E.*, *L.*
Solenia anomala (Pers.) Fr., *L.*
Clavaria amethystina (Batt.) Fr., *S.*, aurea (Schaeff.) Fr., *C.*, *E.*, *S.*, botrytis (Pers.) Fr., *C.*, cinerea (Bull.) Fr., *I.*, *L.*, corniculata (Schaeff.) Fr., *C.*, and var. pratensis (Fr.) Cott. & Wakef., *S.*, cristata (Holmsk.) Fr., *C.*, *S.*, flaccida Fr., *I.*, formosa (Pers.) Fr., *C.*, *S.*, fusiformis (Sow.) Fr., *L.*, Kunzei Fr., *C.*, luteoalba Rea, *C.*, *E.*, pallida Schaeff., *I.*, pistillaris (Linn.) Fr., *E.*, stricta (Pers.) Fr., *L.*, tenuipes B. & Br., *E.*, truncata Quél., *E.*, *S.*, vermicularis Fr., *L.*
Auricularia auricula-Judae (Linn.) Schroet., *Y.*, polytricha (Mont.) Pat., *Chi.*
Tremella reticulata (Berk.) Farl., *S.*
Guepinia helvelloides (DC.) Fr., *I.*
Tremellodon gelatinosum (Scop.) Pers., *C.*
Sebacina incrustans (Pers.) Tul., *E.*, *L.*
Tremellodendron candidum (Schw.) Atk., *E.*, *I.*, pallidum (Schw.) Burt., *C.*
Dacryomitra glossoides (Pers.) Bref., *C.*
Calocera cornea (Batsch) Fr., *L.*, viscosa (Pers.) Fr., *S.*

PYRENOMYCETAE.

Hypomyces lactifluorum (Schw.) Tul., *C.*, *L.*, *M.*, torminosus Tul., *L.*
Claviceps nigricans Tul., *Y.*, on *Eleocharis palustris*.
Endothia parasitica (Murr.) And., *C.*, *W.*, *N.Y.*

TUBERACEAE.

Onygena equina (Willd.) Pers., *E.*

DISCOMYCETAE.

Helvella crispa (Scop.) Fr., *Chi.*, elastica (Bull.) Boud., *Chi*
Leotia lubrica (Scop.) Pers., *Cin.*
Taphrina Alni-incanae (Kühn) Sadeb., *L.*
Spathularia velutipes Cke. & Farl., *C.*
Haematomyces faginea Peck, *L.*

NOTES ON BASIDIOMYCETES GROWN IN CULTURE.

By K. St G. Cartwright.

(With four Text-figures.)

I. The occurrence of abnormal fructifications in *Lenzites saepiaria*.

Abnormal fruiting bodies of *L. saepiaria* have been described by Falck* in his monograph on *Lenzites*; but it appears that these abnormal forms are not generally known owing to the fact that the cultural study of these fungi has received little attention in this country until recently.

The writer is making a special study of lignicolous Basidiomycetes grown on artificial media, with the object of forming a type collection for diagnostic use in his work as mycologist under the Forest Products Research Laboratory, Princes Risborough. It has been found that many abnormal types of fruit-bodies are formed when grown under such conditions, and these often differ so far from the typical form as to be unrecognisable and would certainly be placed in different genera if their origin were not known.

The abnormal fruit-bodies are generally more primitive in type, and, often, in a single culture, several forms may arise in succession. Sometimes, generally in an old culture, the typical form occurs also, which may be normal in all respects, but is usually much smaller.

The abnormal forms, in my experience, usually occur in such genera as *Polyporus*, *Trametes*, *Daedalea*, and *Lenzites*, whereas in the Agarics, although abnormalities occur, they usually consist merely of abortive forms in which the pileus is imperfectly developed or even absent. In these also it is very general to find that there is an increase in the amount of sterile tissue such as the stipe, at the expense of the fertile, but a decrease in size may be the only feature in which they differ from the normal. In the Polyporaceae, etc., on the other hand, the abnormal forms appear as a rule less specialised, the sterile tissue being sacrificed to the fertile. Owing to this, it seems probable that some, at any rate, of the species at present placed in such groups as *Irpex*, *Corticium*, etc. may be merely fruiting forms of *Polyporus*, *Trametes*, *Lenzites* or other genera of the higher groups.

* R. Falck, Die Lenzitesfäule der Coniferenholzes in A. Möller, Hausschwammforschungen, III (1909), 1–234.

Lenzites saepiaria.

Cultures of *Lenzites saepiaria* were obtained from portions of sporophore tissue taken from a fruit-body obtained at Aviemore on the Autumn foray of the Society in September 1927, found growing on a fallen coniferous log.

The culture medium employed was a 2 per cent. extract of Kepler's malt in agar-agar slanted in test tubes and also poured

Fig. 1. *Lenzites saepiaria.* Culture on malt-agar. Top view.

into Petri dishes. Some of the cultures were kept at laboratory temperature whilst others were incubated at 22° C.

In certain of the cultures, after a minimum of about three weeks' growth, white cushions were formed, composed of aerial mycelium, these cushions being occasionally slightly stipitate. They gradually changed colour, passing through varying shades of yellow until, at maturity, the colour varied from cinnamon to Prout's brown (Ridgeway's Colour Standards). The whole fructification approximated in general form to that of a "*Sparassis*" with bifurcating tips, but the tips might be branched

or unbranched. The individual segments were flattened, though not to such an extent as to approach lamellae or gills in appearance.

Photographs of one such fructification are reproduced in Figs. 1 and 2. The centre and base of the fructification was formed of sterile, somewhat fibrous coloured hyphae loosely woven together, which were very uniform in diameter and had

Fig. 2. *Lenzites saepiaria.* Culture on malt-agar. Side view.

septa only at rare intervals. The whole of the outer surface of the segments bore a normal hymenial surface consisting of basidia bearing from two to four spores on well-marked sterigmata; a few sterile hyphae were sometimes present amongst the basidia. The subhymenial layer showed clamps of the normal type and no medallions have been observed in cultures grown on artificial media, neither were clamps present on the fibrous hyphae.

In addition to this form, a less specialised type of fructification also occurred which resembled a coloured *Corticium*. This

second type occurred both in cultures in which the "*Sparassis*" type was present and also in others in which it was absent, and appeared more freely on Petri dish cultures than on test tube slants.

They varied greatly in form, some appearing as slightly raised cushions scattered over the surface of the culture, others were hardly raised above the level of the surrounding mycelium and were often widely effused. The colour in some was capucine yellow though as a general rule, when mature, it ranged from cinnamon rufous, russet brown or mikado brown (Ridgeway).

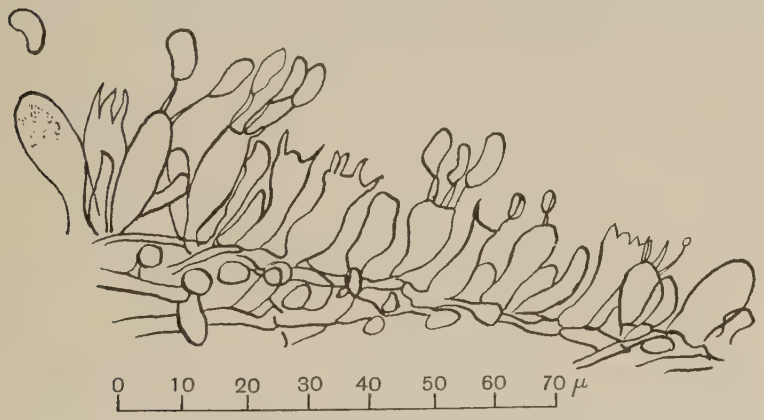


Fig. 3. Hymenium of *Lenzites saepiaria*. × 500.

The hymenial layer occurred all over the surface and basidia were also found borne directly on the mycelium with apparently no specialised hymenial layer.

The spores were found to be viable, and in fact they differed in no respect from those borne on normal fruit-bodies except that they were usually shorter in length, the breadth range remaining unaltered.

A form approaching the Hydnoid type occurred on a culture.

Measurements.

"*Sparassis*" *type of fruit-body*. Size very variable—of little or no significance. The largest seen measured 1·3 cm. high by 1·5 cm. in diameter, and was globular with a small sterile basal portion. It arose as a sterile homogeneous cushion from which the segments developed later, giving it a coralloid appearance.

The individual segments were about 0·3–0·4 cm. high by 0·1 cm. in the broadest part.

Basidia: up to 20 × 5–8μ.

Sterigmata: 2–4μ.

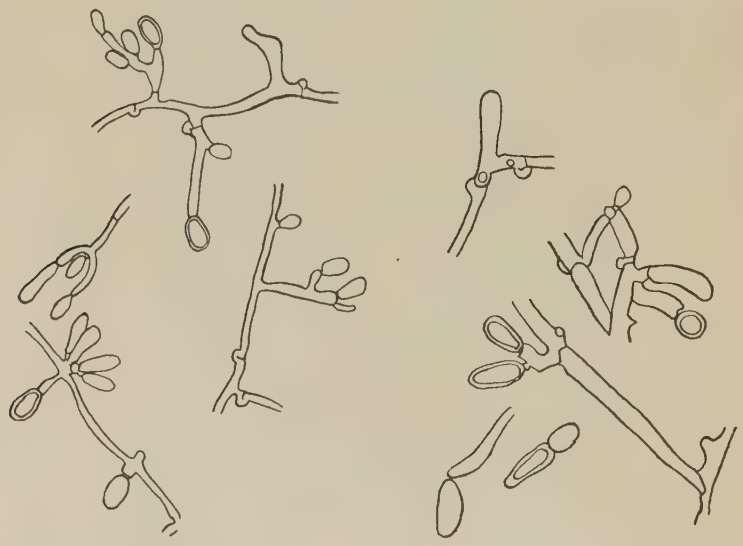
Spores: white, cylindrical, curved, 6–8 × 3–3·5μ.

Fibrous hyphae: 3–3·3μ.

There was little difference in the measurements of the *Corticium* type.

II. Secondary spore formation in *Pholiota adiposa* Fr.

Cultures of *Pholiota adiposa* were made from sporophore tissue. The mycelium grows rapidly on both 2 per cent. prune- or malt-agar. It is at first white, later showing colour changes



Text-fig. 4 *Pholiota adiposa* Fr. Two weeks old culture grown on 2 p.c. malt agur. × 500.

from orange-buff, ochraceous or cinnamon-buff to ochraceous-orange. In old cultures the whole surface tends to become ochraceous-orange and is felt-like or sometimes like cotton wool in texture.

The intensity and rapidity of the colour changes tend to be reduced or delayed when the fungus is grown in darkness, but the same range of coloration is often seen.

Secondary spore formation is always profuse and commences in ten to fourteen days.

These spores are formed both in the submerged and the aerial mycelium and occur in clusters, being more numerous on the aerial hyphae.

They are spherical to ovoid, measuring from 8–13 × 4–6 μ with walls 1·5 μ thick (in the ovoid type) and are abstricted from the ends of much branched hyphae.

These hyphae show numerous clamp connections of the simple type and average 2·5 μ in diameter. The spores are colourless or nearly so.

The fungus fruits readily in culture both on malt and prune.

The sporophores are usually small though otherwise typical, produced as a rule after about fifty six days from the time of inoculation. Cultures fruit more readily when exposed to light, but sporophores may be formed in cultures kept in the dark.

A sporophore produced on prune-agar measured 17 cm. in diameter with a stipe 18 × 1·5–2 cm. The spores measured 6–7 × 3–5 μ.

NOTE.

ARMILLARIA MELLEA IN A MINE-WORKING.

(With two Text-figures.)

Some time ago my friend, Mr L. C. Kemp of Mountfield, Sussex,

Fig. 1. Mass of rhizomorphs with pieces of rock, taken from the working.

sent me some "roots" taken from a mine-working at Fauld, near Tutbury, Staffs., which proved on examination to be rhizomorphs of *Armillaria mellea*. As the conditions under

which these were found are interesting, it is thought they might be worth recording.

At Tutbury a tunnel was being driven into a hill for the purpose of extracting gypsum, and rhizomorphs were found in the tunnel at a point eighty feet below the surface of the ground. The gypsum had been partly dissolved away by water and the holes thus formed had become filled naturally with the red marl of the local rock. The rhizomorphs were in the fissures and seemed to have grown down from the surface of the ground. They were in their natural position and had not been washed into place or mixed with the soil during the process of excavation. However, on the opposite side of the hill was an old working which aroused suspicion. The timber used for props in this working was chiefly elm that had been cut in the neighbourhood and put into position while still green in 1913. After some time a fall occurred and the working was abandoned and has not been used for ten years; the fall was said to be due not to faulty timber but to faulty timbering. Specimens of timber outside the fall examined for *Armillaria mellea* had fragments of rhizomorphs attached, and it was known that there were several sets of timber at the end of the old heading.

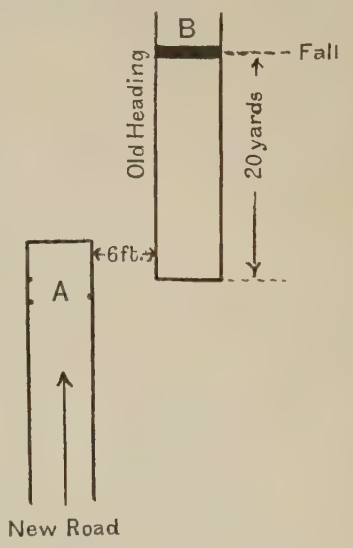


Fig. 2.

The new working was being driven in on the opposite side of the hill and was six feet away from the old heading when the fungus was found. The sketch (supplied to me by Mr G. W. Allen, the mining engineer in charge) explains the circumstances better than would a written description. *A* marks the position where the rhizomorphs were first found, and *B* the position where they were found attached to the timber.

Apparently the mass of rhizomorphs had penetrated from the old heading to the new road by way of the fissures in the marl and gypsum made by water action. Large holes were found in the rock; in places up to two feet in diameter.

There was an abundant supply of the material and "a sack full could have been collected."

It is interesting to note that one of the workmen, who drove a tunnel into the same hill forty years ago within a hundred

yards of the present work, claims to have seen cords similar to those now reported, but had taken them to be roots.

The rhizomorphs are of the circular underground type, not the flattened anastomosing *Rhizomorpha subcorticalis* type. No fruit-bodies of *Armillaria mellea* were evident when the rhizomorphs were found, but workmen reported that a few toadstools had been seen on the timber in the old heading.

E. H. ELLIS.

PROCEEDINGS, 1929.

MEETING. UNIVERSITY COLLEGE, LONDON. *26th January.*

D. M. Cayley. Some Observations on the genus *Didymium.*

A. Chaston Chapman. A New Species of *Oidium.*

E. H. M. Farries. An Investigation on the Metabolism of *Nematospora Gossypii,* Ashby and Nowell.

M. Mitra. *Phytophthora parasitica* Dast., as a Parasite on Cotton Seedlings and Guava Fruits.

A. Smith. Observations on *Puccinia Menthæ* Pers.

MEETING. UNIVERSITY COLLEGE, LONDON. *16th March.*

C. R. Metcalfe. Shab Disease of Lavender.

G. H. Pethybridge. Exhibit of an Unusual Hypertrophy in Potato Tubers due to *Spongospora.*

K. Sampson. Some Observations on *Epichloë typhina* (Pers). Tul.

R. S. Vasudeva. On the Parasitic Invasion of Apple Fruit by Various Fungi.

W. R. D. Weston. The Relative Resistance of some Wheat Varieties to *Tilletia Caries* (D.C.) Tul. (*T. Tritici* Wint.)

SPRING FORAY, PETERSFIELD. *17th–21st May.*

LIST OF MEMBERS, 1929.

Honorary Members.

Lister, Miss Gulielma, F.L.S., 871, High Road, Leytonstone, Essex. (1903.) (1924.)

Rea, Mr Carleton, B.C.L., M.A., 6, Barbourne Terrace, Worcester. (1896.) (1918.)

Smith, Miss Annie Lorrain, F.L.S., 20, Talgarth Road, West Kensington, London, W. 14. (1899.) (1924.)

Thaxter, Professor Roland, 20, Divinity Avenue, Cambridge 38, Mass., U.S.A. (1920.)

Ordinary Members.

1. Aberdeen, The University Library. (1916.)
2. Adams, Rev. J. H., The Vicarage, Kidderminster. (1919.)
3. Adcock, Mr Archie, Upton Road, Norwich. (1921.)
4. Alcock, Mrs N. L., Royal Botanic Gardens, Edinburgh. (1919.)
5. Ali, Mr M. N., Forestry Department, H.E.H. The Nizam's Dominions, Hyderabad, India. (1926.)
6. Allen, Miss I. M., 4, Cunningham Avenue, St Albans, Herts. (1922.)
7. Ashby, Mr S. F., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1926.)
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9. Barnes, Mr B., Ph.D., Birkbeck College, Bream's Buildings, Chancery Lane, London, E.C. 4. (1922.)
10. Barnett, Miss E. C., B.Sc., West of Scotland Agricultural College, 6, Blythswood Square, Glasgow. (1921.)
11. Barr, Rev. Robert, T.D., M.A., The Manse, Neilston, Renfrewshire. (1918.)
12. Barrington, Dr F. J. F., University College Hospital, Medical School, University Street, London, W.C. 1. (1901.)
13. Bartlett, Mr A. W., M.A., B.Sc., Department of Botany, Armstrong College, Newcastle-on-Tyne. (1920.)
14. Bates, Mrs L. F., B.Sc., 36, Gainsborough Gardens, Golders Green, London, N.W. 11. (1921.)
15. Beaumont, Mr Albert, B.A., Seale-Hayne Agricultural College, Newton Abbot, Devon. (1924.)
16. Bewley, Mr W. F., D.Sc., Experimental and Research Station, Cheshunt, Herts. (1922.)
17. Biffen, Professor Sir Rowland H., M.A., F.R.S., 136, Huntingdon Road, Cambridge. (1899.)
18. Birmingham Natural History and Philosophical Society, c/o G. T. Calvert, Esq., Hon. Librarian, Avebury House, 55, Newhall Street, Birmingham. (1920.)

19. Bisby, Mr Guy R., Ph.D., Manitoba Agricultural College, Winnipeg, Canada. (1921.)
20. Blackman, Professor V. H., M.A., F.R.S., Imperial College of Science, South Kensington, London, S.W. 7. (1900.)
21. Blackwell, Miss Elsie M., M.Sc., Botanical Department, Royal Holloway College, Englefield Green, Surrey. (1917.)
22. Blagden, Mr C. O., School of Oriental Studies, Finsbury Circus, London, E.C. 2. (1910.)
23. Bloom, Mr James Harvey, M.A., 36, Ryde Vale Road, Balham, London, S.W. 12. (1915.)
24. Bolas, Mr B. D., 60, Grove Park Terrace, Chiswick, London, W. 4. (1924.)
25. Borthwick, Professor A. W., D.Sc., Forestry Department, The University, Aberdeen. (1911.)
26. Boston, The Mycological Club, c/o Miss Jennie F. Conant, 26, Prospect Street, Melrose, Mass., U.S.A. (1906.)
27. Bradshaw, Mr F., M.A., D.Sc., Armstrong College, Newcastle-on-Tyne. (1928.)
28. Braid, Professor K. W., B.A., B.Sc., West of Scotland Agricultural College, 6, Blythswood Square, Glasgow. (1922.)
29. Brazier, Mr E., Ty'n-y-gongl, Love Lane, Stourbridge. (1921.)
30. Brenchley, Mr G. H., B.A., Clare College, Cambridge. (1925.)
31. Brett, Miss M., M.Sc., Northern Polytechnic, Holloway Road, London, N. 7. (1921.)
32. Briant, Mr A. K., B.A., Imperial College of Tropical Agriculture, St Augustine, Trinidad, B.W.I. (1927.)
33. Brierley, Mr W. B., D.Sc., F.R.A.I., F.L.S., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919.)
34. Bright, Mr T. B., Chucks Cottage, Walton-on-the-Hill, Surrey. (1927.)
35. British Museum, The Trustees of, Cromwell Road, South Kensington, London, S.W. 7. (1914.)
36. Briton-Jones, Professor H. R., D.Sc., Ph.D., D.I.C., A.R.C.S., Imperial College of Tropical Agriculture, St Augustine, Trinidad, B.W.I. (1923.)
37. Brittlebank, Mr C. C., Produce Offices, 607, Flinders Street, Melbourne, Victoria, Australia. (1921.)
38. Brooks, Mr F. T., M.A., The Botany School, Cambridge. (1907.)
39. Brown University, Library, East Side Station, Providence, R.I., U.S.A. (1920.)
40. Brown, Mr W., M.A., D.Sc., Imperial College of Science, South Kensington, London, S.W. 7. (1922.)
41. Bruxelles, Jardin Botanique de l'État, c/o M. P. van Aerdschot. (1911.)

42. Bryce, Mr G., D.Sc., Director, Rubber Research Institute, Kuala Lumpur, Federated Malay Straits. (1915.)
43. Buckley, Mr W. D., "Lynmouth," 2, Curzon Street, Slough. (1916.)
44. Buddin, Mr Walter, M.A., Laboratory of Plant Pathology, University of Reading, 7, Redlands Road, Reading. (1921.)
45. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.S.C., University of Manitoba, Winnipeg, Canada. (1911.)
46. Bunker, Mr H. J., B.A., "Lindau," Hatherden Avenue, Danecourt Road, Parkstone, Dorset. (1925.)
47. Bunting, Mr R. H., F.L.S., Agricultural Department, Aburi, Gold Coast Colony, West Africa. (1921.)
48. Bunyard, Mr G. N., F.L.S., 25, Bower Mount Road, Maidstone, Kent. (1920.)
49. Burgess, Mr R., M.Sc., British Research Association for the Woollen and Worsted Industries, Torridon, Headingley, Leeds. (1928.)
50. Burr, Mr S., The Agriculture Department, The University, Leeds. (1924.)
51. Butcher, Mr R. W., B.Sc., Fisheries Research Station, Alresford, Hants. (1922.)
52. Butler, Mr E. J., C.I.E., D.Sc., F.R.S., M.B., F.L.S., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1920.)
53. Butler, Mr R. R., M.Sc., A.I.C., Chemical Department, Municipal Technical School, Plymouth, Devon. (1924.)
54. Cadman, Miss E. J., c/o Mackay, 111, Dudley Avenue, Leith, near Edinburgh. (1921.)
55. Cambridge, The Botany School. (1920.)
56. Cape Town, Union of South Africa, The Mycologist (91410), Department of Agriculture. (1922.)
57. Carne, Mr W. M., F.L.S., Department of Agriculture, Perth, Western Australia. (1928.)
58. Carr, Professor J. W., M.A., Public Natural History Museum, Wollaton Hall, Nottingham. (1896.)
59. Carrothers, Mr E. N., 145, Stranmillis Road, Belfast, N. Ireland. (1925.)
60. Cartwright, Mr K. St G., B.A., New House Farm, Hughenden, Bucks. (1913.)
61. Castellani, Sir Aldo, M.D., 33, Harley Street, London, W. 1. (1922.)
62. Cayley, Miss Dorothy M., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1913.)
63. Chapman, Mr A. Chaston, F.R.S., F.I.C., Chemical Laboratories, 8, Duke Street, London, E.C. 3. (1926.)
64. Charles, Mr J. H. V., Biochemical Laboratory, Ardeer Factory, Nobel's Explosives Co., Ltd., Stevenston, Ayrshire. (1922.)

65. Chaudhuri, Mr H., M.Sc., Ph.D., University of the Punjab, Lahore, India. (1920.)
66. Cheal, Mr W. F., Kirton Agricultural Institute, Kirton, Nr Boston, Lincs. (1927.)
67. Cheel, Mr Edwin, Botanic Gardens, Sydney, New South Wales, Australia. (1919.)
68. Chona, Mr B. L., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1929.)
69. Ciferri, Dr R., Director, Estación Nacional Agronómica y Colegio de Agricultura, Moca, Dominican Republic, W.I. (1926.)
70. Cleland, Mr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia. (1918.)
71. Clement, Mr E., 189, Upper Grosvenor Road, Tunbridge Wells, Kent. (1927.)
72. Coimbatore, The Librarian, Agricultural College, Madras, South India. (1929.)
73. Connecticut Agricultural Experiment Station, New Haven, Connecticut, U.S.A. (1929.)
74. Cook, Mr W. R. I., Ph.D., Department of Botany, King's College, Strand, London, W.C. 2. (1924.)
75. Cooper, Miss Charlotte A., California Lane, Bushey Heath, Herts. (1911.)
76. Cooper, Mrs V. Astley, Clerdoun, Epsom Road, Ewell, Surrey. (1921.)
77. Copenhagen, Universitets-Bibliothek, c/o P. Haase & Son, Løvstraede 8, København K., Denmark. (1923.)
78. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y., U.S.A. (1920.)
79. Corner, Mr E. J. H., B.A., Assistant Director, Botanic Garden, Singapore, Straits Settlements. (1924.)
80. Cory, Mr F. M., Botanical Department, The University, Bristol. (1926.)
81. Cotton, Mr Arthur D., F.L.S., Keeper, Herbarium, Royal Botanic Gardens, Kew, Surrey. (1902.)
82. Crawford, Miss J. M., The Vicarage, Lyford Road, Wandsworth Common, London, S.W. 18. (1926.)
83. Crow, Mr W. B., M.Sc., Ph.D., F.L.S., Department of Biology, Technical College, Huddersfield. (1921.)
84. Cunningham, Mr G. H., Plant Research Station, Box 240, Palmerston North, New Zealand. (1922.)
85. Curtis, Miss Kathleen M., M.A., D.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand. (1917.)
86. Cutting, Mr E. M., M.A., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1920.)
87. Dade, Mr H. A., A.R.C.S., Department of Agriculture, Aburi, Gold Coast, West Africa. (1927.)

88. Darbishire, Professor O. V., B.A., Ph.D., F.L.S., The University, Bristol. (1913.)
89. Das, Mr Kedarnath, C.I.E., M.D., Principal, Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1922.)
90. Davies, Mr D. W., B.Sc., Adviser in Mycology, Agricultural Buildings, University College of Wales, Aberystwyth. (1923.)
91. Davies, Miss E. M., B.Sc., Woodford School, East Croydon, Surrey. (1928.)
92. Davis, Mr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wis., U.S.A. (1921.)
93. Day, Mr E. Metcalfe, Rowan Cottage, Minchinhampton, Glos. (1921.)
94. Day, Mr W. R., B.A., B.Sc., Imperial Forestry Institute, Oxford. (1928.)
95. Dehra Dun, The Forest Botanist, Forest Research Institute and College, U.P., India. (1929.)
96. Deighton, Mr F. C., B.A., Mycologist, Department of Lands and Forests, Freetown, Sierra Leone, West Africa. (1925.)
97. Dickinson, Mr S., Botanical Department, University College, Cardiff, S. Wales. (1921.)
98. Dickson, Mr B. T., B.A., Ph.D., Senior Mycologist, Council for Scientific and Industrial Research, 314, Albert Street, East Melbourne, Australia. (1923.)
99. Diggle, Major P. G. W., c/o National Bank of Egypt, 6, King William Street, London, E.C. (1926.)
100. Dodge, Dr Carroll W., Farlow Herbarium, 20, Divinity Avenue, Cambridge 38, Mass., U.S.A. (1926.)
101. Dowson, Mr W. J., M.A., Department of Agriculture, Launceston, Tasmania. (1920.)
102. East African Agricultural Research Station, Amani, *via* Tanga, Tanganyika Territory, East Africa. (1929.)
103. Edwards, Mr W. H., Belle Vue, Barline, Beer, Devon. (1896.)
104. Elliot, Rev. E. A., Great Longstone, Derbyshire. (1923.)
105. Elliott, Mr W. T., D.D.S., L.D.S., F.L.S., F.Z.S., Arden Grange, Tanworth-in-Arden, Warwickshire. (1913.)
106. Elliott, Mrs J. S. Bayliss, D.Sc. (B'ham), B.Sc. (Lond.), Arden Grange, Tanworth-in-Arden, Warwickshire. (1911.)
107. Ellis, Mr E. H., Department of Botany, British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7. (1924.)
108. Ellis, Mr Holmes, F.R.M.S., 23, Townley Street, Colne, Lancs. (1927.)
109. Emoto, Dr Y., Tokugawa Biological Institute, Ebara-Gun, Tokyo-Fu, Japan. (1929.)
110. Engledow, Mr F. L., M.A., School of Agriculture, Cambridge. (1922.)

111. Essex Field Club, c/o Mr Percy Thompson, F.L.S., Essex Museum of Natural History, Romford Road, Stratford, London, E. 15. (1919.)
112. Exeter, Librarian, University College of the South-West of England. (1926.)
113. Eyre, Miss J. C., Maitlands Cottage, Ipplepen, Newton Abbot, Devon. (1915.)
114. Fenton, Mr E. W., M.A., B.Sc., F.L.S., Biology Department, Edinburgh and East of Scotland College of Agriculture, Edinburgh. (1920.)
115. Fikry, Mr Amin, The Botany School, Cambridge. (1927.)
116. Findlay, Mr W. P., B.Sc., A.R.C.S., Courte Falaise, Sevenoaks, Kent. (1928.)
117. Finlayson, Mr Raymond A., F.L.S., Official Seed Testing Station, Huntingdon Road, Cambridge. (1910.)
118. Fry, Miss E. J., "Hazelhurst," Pear Tree Avenue, Bitterne, Southampton. (1923.)
119. Gadd, Mr C. H., D.Sc., Tea Research Institute, Nuwara Eliya, Ceylon. (1921.)
120. Galloway, Mr L. D., 2, Milton Crescent, Cheadle, Cheshire. (1928.)
121. Gardner, Capt. Frederic, c/o Barclays Bank, Jersey, C.I. (1898.)
122. Garside, Mr S., M.Sc., F.L.S., Botanical Department, Bedford College, Regent's Park, London, N.W. 1. (1922.)
123. Gates, Professor R. R., B.Sc., Ph.D., F.L.S., King's College, Strand, London, W.C. 2. (1921.)
124. Gäumann, Dr E. A., Prof. f. spezielle Botanik, Universitätsstrasse 2, Zürich 6, Switzerland. (1928.)
125. Gilbert, Dr E. M., Botanical Department, University of Wisconsin, Madison, Wis., U.S.A. (1922.)
126. Gilbert, M. E., Docteur en Pharmacie, 6, Rue de Laos, Paris (15e), France. (1924.)
127. Good, Mr R. D'Oyley, M.A., Botanical Department, University College, Hull. (1929.)
128. Gorman, Mr M. J., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
129. Gough, Mr G. C., B.Sc., A.R.C.S., Ministry of Agriculture, Cornwall Buildings, 45, Newhall Street, Birmingham. (1923.)
130. Gould, Mr F. G., Elmhurst, Church Hill, Loughton, Essex. (1918.)
131. Green, Col. C. Theodore, A.M.S., M.R.C.S., L.R.C.P., F.L.S., 31, Shrewsbury Road, Birkenhead. (1901.)
132. Green, Miss E., 15, Gower Street, London, W.C. 1. (1925.)
133. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey. (1917.)

134. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, London, S.E. 18. (1913.)
135. Grove, Miss Jessica H., 14, The Tything, Worcester. (1927.)
136. Gunter, Mr Thomas J., 4, Alexandra Road, London, N. 4. (1926.)
137. Gwynne-Vaughan, Professor Dame Helen, D.Sc., LL.D., F.L.S., 93, Bedford Court Mansions, London, W.C. 1. (1906.)
138. Hanna, Mr W. F., M.Sc., Dominion Rust Research Laboratory, Agricultural College, Winnipeg, Canada. (1925.)
139. Hansford, Mr C. G., M.A., Mycologist, Department of Agriculture, Kampala, Uganda. (1921.)
140. Harris, Mr R. V., B.Sc., Horticultural Research Station, East Malling, Kent. (1924.)
141. Harvard University, The Library, Cambridge, Mass., U.S.A. (1923.)
142. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1. (1913.)
143. Hemmi, Dr Takewo, Phytopathological Institute, Department of Agriculture, Kyoto Imperial University, Kyoto, Japan. (1923.)
144. Hildyard, Mr F. W., 14, Lambridge, Bath. (1913.)
145. Hoare, Mr A. H., 14, Hills Road, Cambridge. (1922.)
146. Hoggan, Miss I. A., Department of Plant Pathology, University of Wisconsin, Madison, Wis., U.S.A. (1923.)
147. Holden, Dr H. S., F.L.S., Botanical Department, University College, Nottingham. (1923.)
148. Honolulu, Association of Hawaiian Pineapple Canners, Att. Mr E. Wilson, Hawaii. (1929.)
149. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii. (1920.)
150. Horne, Mr A. S., D.Sc., F.L.S., F.G.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
151. Howard, Mr H. J., F.R.M.S., "Lingfield," 6, College Road, Norwich. (1918.)
152. Howarth, Mr W. O., M.Sc., Botanical Department, The University, Manchester. (1927.)
153. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898.)
154. Hughes, Mr J. S., University Observatory, Oxford. (1927.)
155. Humphrey, Mr C. J., Mycologist and Plant Pathologist, Bureau of Science, Manila, Philippine Islands. (1921.)
156. Hunter, Mrs R., Imperial College of Tropical Agriculture, St Augustine, Trinidad, B.W.I. (1925.)
157. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth. (1921.)
158. Hurst, Mr C. P., Bedwyn, Wilts. (1928.)
159. Hyde, Mr H. A., M.A., F.L.S., National Museum of Wales, Cardiff. (1924.)

160. Imperial College of Tropical Agriculture, Trinidad, B.W.I. (1921.)
161. Iowa, The Library, State University of Iowa, Iowa City, U.S.A. (1923.)
162. Iowa State College, Library, Ames, Iowa, U.S.A. (1927.)
163. Issatchenko, Professor B. L., Directeur du Jardin Botanique, Leningrad, Russia. (1923.)
164. Jaczewski, Professor Arthur de, Director, Institute of Mycology and Phytopathology, Perspective Anglaise 29, Leningrad, Russia. (1922.)
165. John Crerar Library, 86, East Randolph Street, Chicago, Illinois, U.S.A. (1929.)
166. John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1924.)
167. Johnson, Mr J. W. Haigh, M.Sc., F.I.C., F.L.S., Walton, Nr Wakefield. (1919.)
168. Johnstone, Miss K. H., B.A., All Saints' Vicarage, Cheltenham, Glos. (1927.)
169. Johnstone, Mr R. B., 3, Oswald Gardens, Scotstounhill, Glasgow. (1908.)
170. Jones, Mr G. H., M.A., Plant Protection Section, Ministry of Agriculture, Cairo, Egypt. (1922.)
171. Jones, Mr Robert Fowler, Trinity House, Denton Road, Ilkley, Yorks. (1918.)
172. Jørstad, Mr Ivar, Statsmykolog, Botanisk Museum, Oslo, Norway. (1923.)
173. Kavina, Professor Dr Karel, Professor of Botany, Havlickovy-sady 58, Praha-Kral. Vinohrady (Prague), Czechoslovakia. (1926.)
174. Keilin, Dr D., Molteno Institute of Parasitology, Cambridge. (1922.)
175. Keissler, Dr Karl, Direktor d. Botanischen Abteilung, Naturhistorisches Museum, Burgring 7, Wien 1/1, Austria. (1924.)
176. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921.)
177. Kendall, Miss Olwen, 9, Lordship Park, Stoke Newington, London, N. 16. (1921.)
178. Kew, The Library, Royal Botanic Gardens. (1921.)
179. Kidd, Mrs Franklin, B.A., The Botany School, Cambridge. (1919.)
180. Kirby, Mr E. E., B.A., Grafton House, Oxford Street, Norwich. (1924.)
181. Klika, Mr Bohumil, Hálkova 37, Prague, Vrsovice 553, Czechoslovakia. (1926.)
182. Knight, Mr H. H., M.A., The Lodge, All Saints' Villas, Cheltenham. (1914.)

183. Knowles, Miss M. C., M.R.I.A., Natural History Museum, Dublin. (1925.)
184. Krieger, Mr L. C. C., 2114, N. Calvert Street, Baltimore, Md., U.S.A. (1921.)
185. Lampitt, Mr L. H., D.Sc., F.I.C., Thornlea, Mount Park, Harrow, Middlesex. (1925.)
186. Leicester, The Museum, City of Leicester. (1923.)
187. Lewis, Professor F. J., D.Sc., University of Alberta, Edmonton, Alberta, Canada. (1924.)
188. Line, Mr James, M.A., School of Agriculture, Cambridge. (1921.)
189. Linnean Society, The, Burlington House, Piccadilly, London, W. 1. (1919.)
190. Lloyd Library, The, Cincinnati, Ohio, U.S.A. (1907.)
191. Loader, Miss F. M., Botanical Department, University College, Southampton. (1927.)
192. Lowndes, Mr A. G., M.A., Marlborough College, Marlborough, Wilts. (1922.)
193. Macdonald, Mr J., 25, Drumsheugh Gardens, Edinburgh. (1929.)
194. Mackenzie, Miss A. D., Research Station, East Malling, Kent. (1921.)
195. Madras University Library, Senate House, Triplicane, Madras, South India. (1925.)
196. Maire, M. René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algiers, Algeria, N. Africa. (1907.)
197. Maltby, Mr G. C., 14, Northwick Road, Evesham. (1923.)
198. Marsh, Mr R. W., M.A., Research Station, Long Ashton, Bristol. (1923.)
199. Martyn, Mr E. B., B.A., Department of Agriculture, Georgetown, British Guiana. (1927.)
200. Mason, Mr E. W., M.A., M.Sc., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
201. Mason, Mrs E. W., Suffield House, Paradise Road, Richmond, Surrey. (1922.)
202. Mason, Mr F. A., F.R.M.S., M.S.P.A., 29, Frankland Terrace, Leeds. (1912.)
203. Massey, Mr R. E., F.L.S., Government Botanist, Department of Agriculture, Khartoum North, Sudan. (1929.)
204. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh. (1921.)
205. McDonald, Mr J., B.Sc., Mycologist, Department of Agriculture, Box 323, Nairobi, Kenya Colony, East Africa. (1923.)
206. McFarland, Dr Frank T., Department of Botany, University of Kentucky, Lexington, Ky., U.S.A. (1924.)
207. McLean, Professor R. C., M.A., D.Sc., F.L.S., Botany School, University College, Cardiff. (1922.)

208. McLennan, Dr Ethel I., Botanical Department, Melbourne University, Carlton, Victoria, Australia. (1926.)
209. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
210. Metcalfe, Mr C. R., B.A., Westport, Wareham, Dorset. (1926.)
211. Meulenhoff, Dr J. S., Ruychrocklaan 30, The Hague, Holland. (1921.)
212. Michigan Agricultural College Library, East Lansing, Michigan, U.S.A. (1924.)
213. Millard, Mr W. A., B.Sc., The Agriculture Department, The University, Leeds. (1924.)
214. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
215. Mitra, Mr M., Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1928.)
216. Miyabe, Dr Kingo, Professor Emeritus of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
217. Mohendra, Mr K. R., Government Mycologist, Lyallpur, India. (1927.)
218. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
219. Moore, Miss E. S., Ph.D., c/o the Secretary, Department of Agriculture, P.O. Box 994, Pretoria, South Africa. (1923.)
220. Moore, Mr W. C., M.A., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1922.)
221. Morgan, Dr G., Ashley-Hatton, Dyke Road Avenue, Brighton. (1928.)
222. Morris, Mr L. E., Rubber Research Institute, Kuala Lumpur, Federated Malay States. (1924.)
223. Moscow, The Fundamental Bibliothek of the First University of, Mochovaya 9, Moscow, U.S.S.R. (1929.)
224. Moss, Professor C. E., The University, P.O. Box 1176, Johannesburg, South Africa. (1923.)
225. Murphy, Professor P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Department of Plant Pathology, Albert Agricultural College, Glasnevin, Dublin, N.W. 3. (1924.)
226. Murray, Mr G. H., F.E.S., Director of Agriculture, Rabaul, New Britain, Territory of New Guinea, *via* Australia. (1921.)
227. Murrell, Major Percy J., O.B.E., F.R.M.S., "Littlecroft," Orpington, Kent. (1923.)
228. Muskett, Mr A. E., B.Sc., A.R.C.S., Queen's University, Belfast, North Ireland. (1923.)
229. National Collection of Type Cultures, Curator, Lister Institute, Chelsea Gardens, London, S.W. 7. (1921.)
230. Nattrass, Mr R. M., B.Sc. (Agric.), Ph.D., Plant Protection Section, Ministry of Agriculture, Cairo, Egypt. (1925.)
231. Nebraska, The Library, University of, Lincoln, Nebr., U.S.A. (1924.)

232. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Zoomweg 10, Wageningen, Holland. (1920.)
233. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
234. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)
235. Nirula, Mr Ram Lal, Ph.D. (Lond.), D.I.C., Ghangwal, Jhawrian, Sargodha, Punjab, India. (1927.)
236. Noel, Miss E. F., F.L.S., 37, Moscow Court, Queen's Road, London, W. 2. (1913.)
237. Norman, Mr L. Stafford, Konjeni Estate, Luchenza P.O., Nyasaland. (1927.)
238. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
239. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
240. O'Connor, Mr P., B.Sc., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
241. Ogilvie, Mr L., M.A., M.Sc., Research Station, Long Ashton, Nr Bristol. (1922.)
242. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
243. Ontario Agricultural College, Library, Guelph, Ontario, Canada. (1920.)
244. Osborn, Professor T. G. B., M.Sc., Botanical Department, The University, Sydney, N.S.W., Australia. (1910.)
245. Ottawa, Ontario, Canada, The Library, Geological Survey. (1926.)
246. Page, Miss W. M., B.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1. (1921.)
247. Pan, Mr T. C., M.B., Ch.B., A 22, Wai Ma Road, Chang Yuan, Swatow, China. (1925.)
248. Park, Mr M., Department of Agriculture, Peradeniya, Ceylon. (1929.)
249. Parke Davis & Co., Librarian, Research Department, Detroit, Michigan, U.S.A. (1920.)
250. Paul, Mr W. R. C., M.Sc., D.I.C., F.L.S., Department of Agriculture, Peradeniya, Ceylon. (1928.)
251. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex. (1918.)
252. Peacock, Dr H. G., The Lawn, Torquay. (1896.)
253. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
254. Peklo, Dr Jaroslav, Professor of Applied Botany, Bohemian Technical University, Charles Square, Prague II, Czechoslovakia. (1924.)

255. Perthshire Society of Natural Science, c/o Mr James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
256. Petch, Mr T., B.A., B.Sc. (1911.)
257. Pethybridge, Mr G. H., Ph.D., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
258. Philadelphia, The Academy of Natural Sciences of Philadelphia, Logan Square, Phil., U.S.A. (1925.)
259. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 10. (1923.)
260. Phillips, Mr J. F. V., B.Sc. (For.), D.Sc. (Edin.), Botanist (Tsetse Research), Game Preservation Department, Kondoa-Irangi Tanganyika Territory, East Africa. (1921.)
261. Ping, Mr A. Wentworth, M.A., "St Olave's," Clifton, York. (1926.)
262. Plowright, Mr C. T. M., B.A., M.B., King Street, King's Lynn. (1901.)
263. Potter, Rev. M. C., Sc.D., M.A., F.L.S., Corley Croft, New Milton, Hants. (1896.)
264. Povah, Professor A. H., 9, Fisk Hall, Northwestern University, Evanston, Ill., U.S.A. (1924.)
265. Preston, Mr N. C., B.Sc., Harper Adams Agricultural College, Newport, Salop. (1920.)
266. Pretoria, South Africa, The Chief, Division of Botany (91403), Department of Agriculture. (1922.)
267. Priestley, Professor J. H., D.S.O., B.Sc., F.L.S., Botanical Department, The University, Leeds. (1912.)
268. Proefstation voor Thee, Departement van Landbouw, Buitenzorg, Java. (1926.)
269. Pusa, Imperial Mycologist, Imperial Agricultural Research Institute, Pusa, Bihar, India. (1921.)
270. Ramsbottom, Mr J., O.B.E., M.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7. (1910.)
271. Ray, Miss Anne, Penarwyn, Gorran Haven, Gorran, Cornwall. (1929.)
272. Rayner, Mr J. F., Swaythling, Southampton. (1902.)
273. Rayner, Dr M. Cheveley (Mrs Neilson Jones), Bedford College for Women, Regent's Park, London, N.W. 1. (1921.)
274. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Ireland. (1920.)
275. Reichert, Dr Israel, Plant Pathologist, Palestine Zionist Executive Agricultural Experiment Station, Tel-Aviv, Palestine. (1924.)
276. Rhind, Mr Donald, B.Sc., Economic Botanist, Department of Agriculture, Agricultural College, Mandalay, Burma. (1922.)

277. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
278. Rhodes, Rev. P. G. M., Oscott College, Birmingham. (1929.)
279. Richards, Mr R. M., M.B.E., A.R.C.S., F.L.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements. (1915.)
280. Roberts, Mrs A. W. Rymer, The End House, Fulbrooke Road, Cambridge. (1920.)
281. Robinson, Professor Wilfred, Stoneleigh, Caradog Road, Aberystwyth, N. Wales. (1923.)
282. Robson, Mr R., M.Sc., F.Z.S., East Hammingfield, Chelmsford, Essex. (1914.)
283. Roper, Miss Ida M., F.L.S., 4, Woodfield Road, Redland, Bristol. (1921.)
284. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
285. Rutgers College and State University of New Jersey, Library, New Brunswick, New Jersey, U.S.A. (1922.)
286. Ryan, Mr G. M., F.L.S., 35, Ladbroke Gardens, London, W. 11. (1923.)
287. St Paul, Minnesota, U.S.A., The Library, Department of Agriculture, University Farm. (1920.)
288. Salisbury, Professor E. J., D.Sc., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1921.)
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367. Zundel, Dr G. L. I., Botany Building, Pennsylvania State College, State College, Pa., U.S.A. (1929.)

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually, at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex-officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct., 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see Appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see Appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more meetings annually, at a place and time determined by the Members at the preceeding Annual General Meeting, or by the Council. The Annual General Meeting for the election of officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alterations to all Members.

APPENDIX.

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of.....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

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